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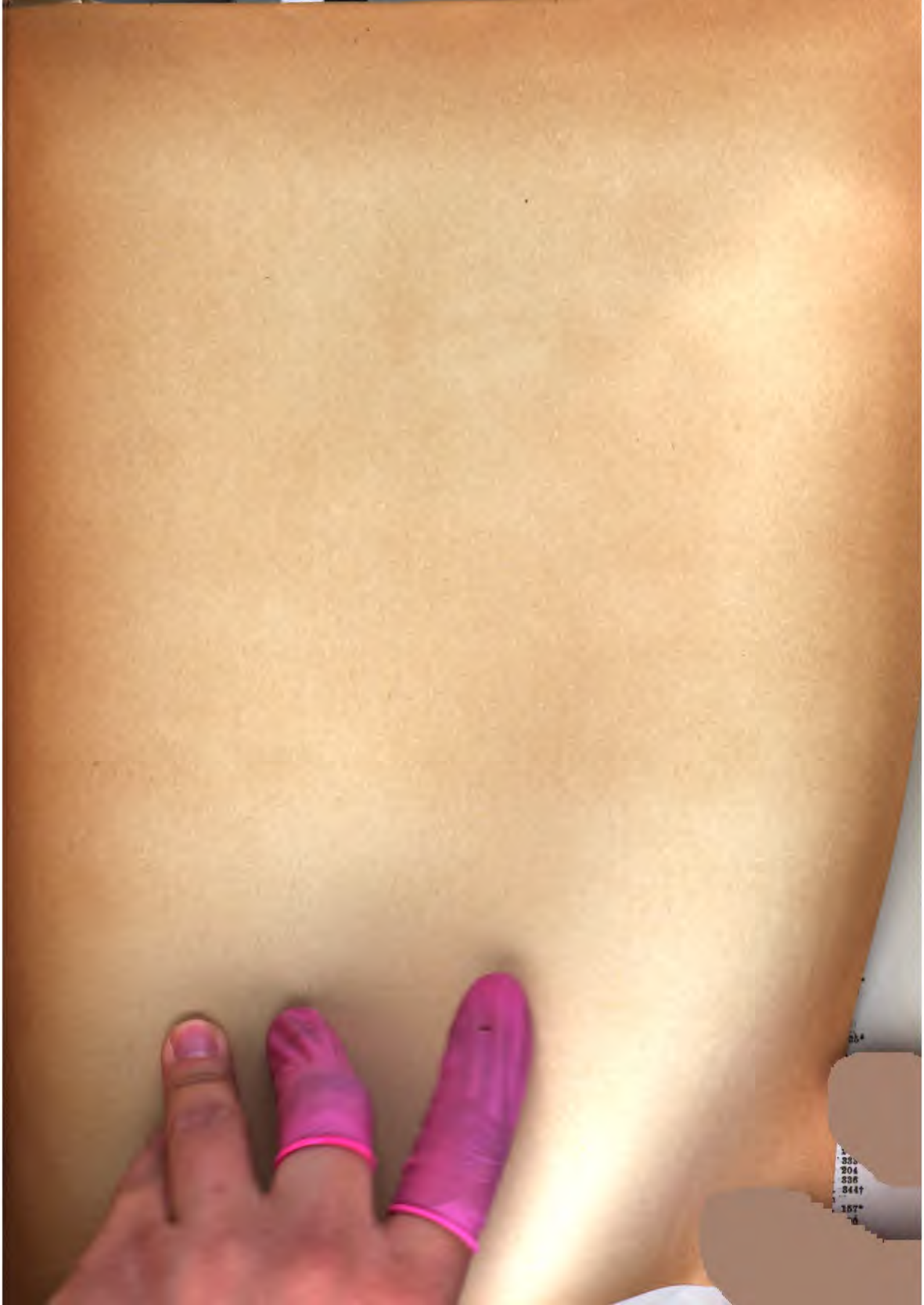

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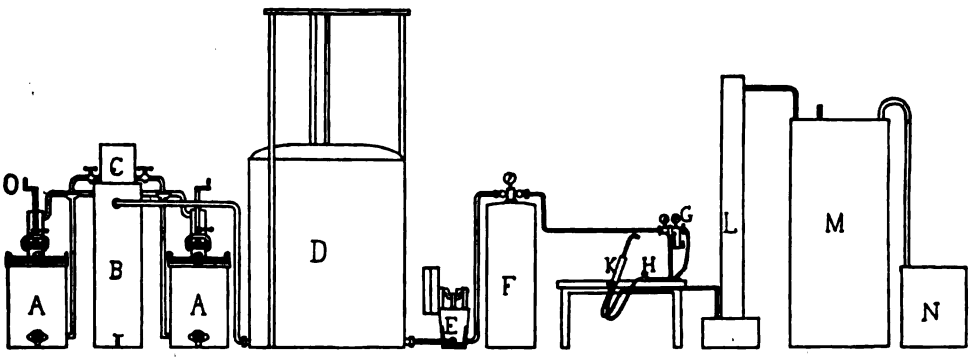
The frames are of cast steel with double front rails of wrought iron. Each rail is double keyed to the main frame. A large cast steel foot plate forms a stubstantial frame bracing at the rear end and is assisted by two pieces of channel iron, which constitute the back bumping plate. The general features of construction are clearly shown in the illustrations and the general dimensions, weights and ratios are shown in the following table:

GENERAL DATA.	
Gauge	4 ft. 8½ in.
Service	Freight
Fuel	Bit. Coal
Tractive effort	44,100 lbs.
Weight in working order	203,600 lbs.
Weight on drivers	182,000 lbs.
Weight on leading truck	21,600 lbs.
Weight of engine and tender in working order	350,000 lbs.
Wheel base, driving	16 ft.
Wheel base, total	24 ft. 8½ in.
Wheel base, engine and tender	56 ft. 7¼ in.
RATIOS.	
Weight on drivers ÷ tractive effort	4.13
Total weight ÷ tractive effort	4.61
Tractive effort x diam. drivers ÷ heating surface	768.00
Total heating surface ÷ grate area	59.80
Firebox heating surface ÷ total heating surface, per cent	5.42
Weight on drivers ÷ total heating surface	56.40
Total weight ÷ total heating surface	63.00
Volume both cylinders, cu. ft.	13.20
Total heating surface ÷ vol. cylinders	244.00
Grate area ÷ vol. cylinders	4.10

CYLINDERS.	
Kind	Simple
Diameter and stroke	22 x 30 in.
VALVES.	
Kind	Bal. Slide
Greatest travel	5½ in.
Outside lap	1 in.
Lead, constant	3/16 in.
WHEELS.	
Driving, diameter over tires	56 in.
Driving, thickness of tires	3 in.
Driving journals, main, diameter and length	10 x 12 in.
Driving journals, others, diameter and length	9 x 12 in.
Engine truck wheels, diameter	33 in.
Engine truck, journals	5½ x 10 in.
BOILER.	
Style	Straight
Working pressure	200 lbs.
Outside diameter of first ring	76 11/16 in.
Firebox, length and width	108 x 71¾ in.
Firebox plates, thickness	⅜ & ½ in.
Firebox, water space	F.-4⅛, S. & B.-3½ in.
Tubes, number and outside diameter	408—2 in.
Tubes, length	14 ft. 6½ in.
Heating surface, tubes	3,051 sq. ft.
Heating surface, firebox	175 sq. ft.
Heating surface, total	3,226 sq. ft.
Grate area	54 sq. ft.
Smokestack, height above rail	180 7/16 in.
Centre of boiler above rail	114¾ in.
TENDER.	
Wheels, diameter	33 in.
Journals, diameter and length	5½ x 10 in.
Water capacity	7,500 gals.
Coal capacity	12½ tons.



ARRANGEMENT OF OXYGEN-ACETYLENE PLANT.

(A to H, oxygen apparatus; L to N, acetylene apparatus; A and A¹, oxygen generators; B, cleaning tower; C, catalyser vessel; O, agitator; D, gasometer; E, compressor; F, pressure-reservoir; G, pressure-regulator; H, cock; K, blowpipe; L, safety valve; M, gasometer for constant pressure; N, acetylene generator.)

OXY-ACETYLENE METHODS OF WELDING AND CUTTING METALS.

It has been customary for a number of years to weld the butt joints of locomotive boiler shells at the ends and other points where they can be reinforced to withstand the pressure, but the idea of welding the joint for its full length, and of obtaining a strength at this point nearly equivalent to the remainder of the sheet and greater than the usual riveted joint, is altogether a new idea on American railways. Such construction, however, has recently been made possible by the perfection of a comparatively simple apparatus for generating pure acetylene gas and pure oxygen and bringing them together in a blow pipe flame, which has a temperature capable of fusing practically any metal. The same flame can also be used for cutting sheets of steel or other material, performing a perfect job with no more waste of metal than would occur with a saw and with the great advantage that sections of irregular shape can be cut as easily as straight.

Acetylene, the properties and generation of which are generally understood, is a gas very rich in carbon, containing as it does about 92.3 per cent., and it is possible to obtain a temperature higher than that of the oxy-hydrogen blow pipe flame (3,600 degs. F.) by its combustion with air in a Bunson burner. When, however, acetylene gas is burned with oxygen instead of air there is produced the hottest flame known, as a product of combustion, which has a temperature of 6,300 degs. F. or very nearly that of an electric arc. By the proper proportions of the two gases this flame can be made absolutely neutral in its action and have neither an oxidizing or carburetting tendency. These facts have been known for a long time, but the inconvenience and cost of obtaining pure oxygen in a commercial manner has prevented the practical use of the knowledge on any large scale.

The comparative recent discovery of a powder, or chemical, called "Euprite," which acts in much the same way as does calcium carbide in the production of acetylene gas and permits the generation of chemically pure oxygen in apparatus similar to the acetylene gas generator, has made it possible to commercially utilize this very high temperature at a comparatively low cost.

One of the illustrations shows a diagrammatical view of the apparatus required for this purpose. The section at the left of the blow pipe (K) is for the generation of the oxygen, and the section to the right is for acetylene gas. Both gases are brought to the blow pipe under pressure, there being automatic pressure regulators and stop valves provided so that the amount and pressure of either gas can be varied at will. The blow pipe is of a size corresponding to the work on which it is to be employed, and the gases should arrive at the nozzle at slightly over 2 lbs. pleasure, which will give an exit speed and flow of the gas through the pipes sufficient to counteract any back burning of the mixture before reaching the end of the blow pipe. Metallic gauzes are also provided to prevent the flame throwing back, and it is said that the danger of accident or explosion with the apparatus is practically eliminated, and that an inexperienced operator is able to control it without danger.

In welding two pieces of any considerable thickness the edges are beveled so that it is possible to heat to the bottom of the weld. The blow pipe flame is directed into the opening until the two edges are fused, and at the same time a rod of the same metal, which is held in the flames, is fused and fills the space between the sheets in much the same manner as in soldering. This work being carefully done, results in a joint which is practically a part of the sheet, and outside of the fact that it has not been possible to work the metal in a joint and thus increase its strength, gives a connection which is equal in strength to any part

THE BROKEN CRANK SHAFT.

READY FOR WELDING.

BEING WELDED.

READY FOR THE MACHINE.

of the sheet. In practice, by building up the metal on top of the joint, and thus giving a greater sectional area, the joint is made nearly equal in strength to the remainder of the sheet.

The same method can be used in repairing boiler or firebox sheets which have cracked along the edges or at staybolts, or been corroded away at certain points, and the sheets restored to their full strength by the building up with new material to any extent desired. Repairs of this nature can be safely considered as an integral part of the sheet rather than as a patch.

The illustrations show a broken crank shaft and the different processes followed in welding the two sections together, making it practically as good as new and at a very slight expense compared to the cost of constructing a new shaft. The work shown in the illustration was performed by the Worcester Pressed Steel Company, which has a plant of this kind in operation.

For cutting sheets the flame, by change in pressure, is somewhat elongated and given somewhat of an oxidizing effect and simply burns a narrow cut through the plate following any desired contour. The edges of the sheet are smooth and even, and plates up to 5 in. in thickness have been cut in this manner.

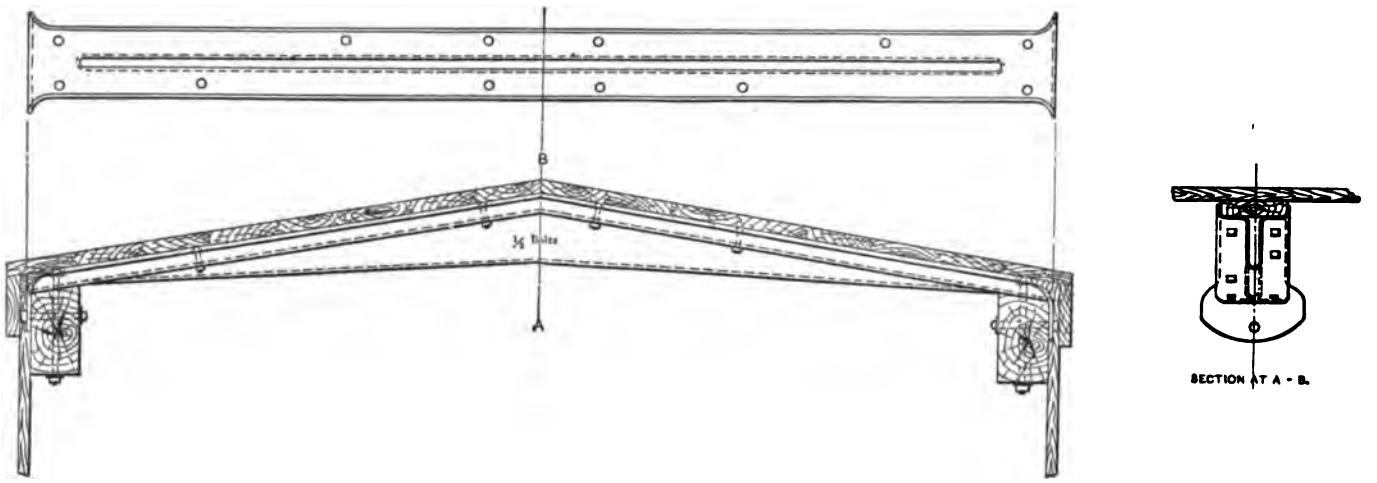
This process is not only adapted for making tanks, boilers, tubing and pipe joints and angles, and for replacing brazing and riveting in many instances, but it also can be used effectively to weld steel castings. Many defective castings have been saved in the foundry by the filling in of the blow holes with new metal or welding together smaller sections of the castings which have been broken apart. It will also, no doubt, prove to be a great time-saver by permitting small leaks or breaks to be repaired without removing the parts from the locomotive.

This system of welding is known as the auto-genous welding and the process and apparatus is controlled by the Industrial Oxygen Company, Hanover Bank Building, 11 Pine Street, New York City.

SHOP LIGHTING.

To furnish the most up-to-date machinery and tools, and pay the present high prices for labor, and then to handicap the workmen by insufficient, or improperly placed lights, is a fallacy too patent to require argument; and still such cases are by no means uncommon. It will perhaps add to the impressiveness of this statement to make use of a few computations. Let us take as a basis the electric light, which is admittedly the most expensive form of artificial illumination, and let us say that the current is purchased at the retail price of 10 cents per unit (kilowatt hour). A 16-candle-power lamp can be burned 18 hours by the use of one unit, that is, at a cost of 10 cents, or 55 mills per hour. The ordinary workman, receiving, say, 20 cents per hour, would only have to lose a trifle over a minute and a half out of an hour to represent a loss equal to the cost of the light; while a skilled workman, receiving, say, 50 cents per hour, would have to lose only a little over half a minute ever hour to represent a similar loss. In other words, the ordinary workman losing 13 minutes in a day of 8 hours, or the skilled workman 5 minutes in the same time, would equal the cost of running the lamp for the entire working day. But instead of electricity costing 10 cents per unit, it may be generated in large works, where power is already at hand, as well as the fixed charges of superintendence, etc., as low as 2 cents per unit, which would reduce the above figures to one-fifth; that is, the average workman would have to lose only about 2½ minutes in an entire working day of 8 hours, and the skilled workman but a little over a minute, to represent the cost of the lamp for a day. But the loss in wages is not all; loss in time of the operative represents a loss from the non-use of the machine. And again, besides there being a reduction in the amount of product, there is often a reduction in quality also, which is far more serious than the reduction in quantity.—*The Illuminating Engineer.*

PRODUCER GAS ENGINE PLANT MOST ECONOMICAL.—Personally, I believe that a gas-engine plant, making its own producer gas, will operate at least as reliably as a steam plant and will use from 30 to 60 per cent. less fuel, depending principally on the size of the steam plant. The drawbacks to the gas plant are, in my mind, the first cost, approximating $200 per kilowatt when rated so as to have a 33⅓ per cent. overload capacity, and the small size of units—the largest gas engine now built being only of about 3,000 kilowatt capacity.—*Paul Winsor before the Amer. Street and Interurban Ry. Eng. Assoc.*



CLEVELAND PRESSED STEEL CARLINE.

PRESSED STEEL CARLINES.

One of the most important developments in box car design and construction has been the introduction of pressed steel carlines. That this type of carline is made in one piece and that it can be used to replace the wooden carline without any change in the construction of either the car body or the roof, are important points in its favor. Compared to the wooden carline a stronger roof support may be gained with a less number of steel carlines, with less weight per car, and in most cases with greater inside clearance.

The Cleveland Car Specialty Company of Cleveland has designed a new pattern of pressed steel carline, specially adapted to the outside metal roof, in which a channel section is reinforced by a U-section pressed into the web of the channel. The channel section, with a 5-in. nailing strip bolted to it, gives a wide support for the longitudinal course of boards and the additional strength due to the U-section makes a stronger carline with less weight than any possible combination of wood and iron, or any commercial shape that may be used.

The importance of adding strength to freight cars without increasing their weight is generally recognized. Tests and experiments show that in practically all cases a pressed steel shape will give better results in this respect than commercial shapes, as additional strength may readily be provided where it is required. This is specially true of compound shapes, which must be built up and bolted or riveted together.

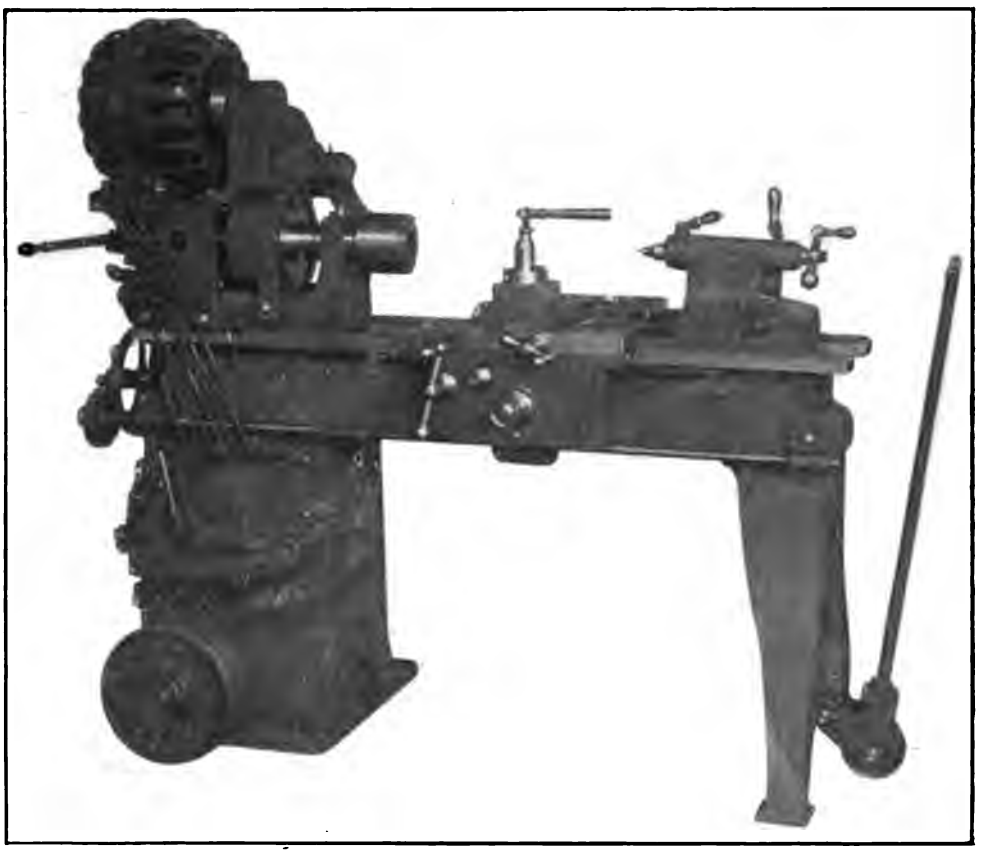
The Cleveland pressed steel carlines are made in a number of different patterns suitable for different types of construction. The new type, which has been described, is said to be an ideal one for the outside metal roof, combining, as it does, the superior design with lightness, and extending over the side plates.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION.—The International Railway and the Master Steam Boiler Makers' Associations consolidated last spring to form this Association. The next convention will be held in Detroit, May 26, 27 and 28. Mr. George Wagstaff, supervisor of boilers of the New York Central Lines, is its president.

PORTABLE LATHE FOR ERECTING SHOPS.

A portable bolt turning machine is being used to considerable advantage in the erecting shop of the Canadian Pacific Railway at Angus, Montreal. The base is provided with three wheels which are fitted with roller bearings. When the handle is in an upright position the two forward legs of the bed rest on the floor and the machine is level. When the handle is pulled forward these legs are raised from the floor, the weight resting on the small front wheel, and the machine may be easily moved from place to place. Three-quarters of the weight rests upon the two large wheels at the rear.

The machine is driven by a 2 h.p. Westinghouse induction motor, 1,700 r. p. m., the starting device for which is shown at the front of the machine. The gearing is arranged for either 200 or 400 revolutions per minute of the lathe spindle; change from one speed to the other is made by moving the lever which controls the friction clutches. The nose of the spindle is fitted with a chuck, suitable to the size of bolt which is being turned and into which the bolt head fits. This merely drives the work,



PORTABLE LATHE FOR ERECTING SHOPS.

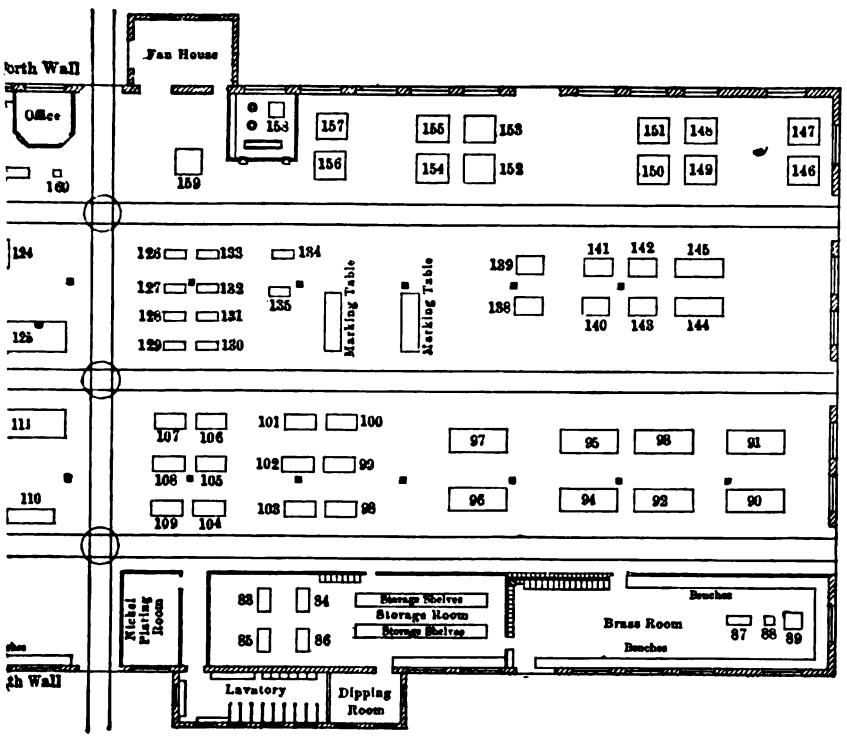


FIG. 31.—PARTIAL PLAN OF THE CAR MACHINE SHOP.

CAR MACHINE SHOP.

No.	Name and Maker.	Motor H. P.
83.	Double buffer	10
84.	Double buffer	
85.	Double buffer	
86.	Double buffer	
87.	¾-in. turret lathe, Bertram & Sons	5
88.	16-in. sliding head drill press, Hamilton Machine Tool Company.	
89.	Miller, Smith & Coventry	
90.	6-spindle arch bar drill, Niles Tool Works	
91.	6-spindle arch bar drill, Bertram & Sons	
92.	6-spindle drill	30
93.	6-spindle arch bar drill, Bertram & Sons	
94.	6-spindle drill, Bertram & Sons	
95.	6-spindle drill, Bertram & Sons	
96.	6-spindle drill, Bertram & Sons	
97.	6-spindle drill, Bertram & Sons	
98.	32-in. vertical drill, Bertram & Sons	
99.	28-in. vertical drill, Cincinnati Machine Tool Company	
100.	26-in. vertical drill, Bertram & Sons	
101.	28-in. vertical drill, Cincinnati Machine Tool Company	
102.	28-in. vertical drill, Cincinnati Machine Tool Company	
103.	28-in. vertical drill, McGregor & Gourley	15
104.	26-in. vertical drill, Prentice Bros.	
105.	20-in. vertical drill, Prentiss	
106.	20-in. vertical drill	
107.	30-in. vertical drill	
108.	26-in. vertical drill, Bertram & Sons	
109.	25-in. vertical drill, Bertram & Sons	
126.	6-in. small vertical drill, C. P. R.	
127.	6-in. small vertical drill, C. P. R.	
128.	6-in. small vertical drill, C. P. R.	
129.	6-in. small vertical drill, C. P. R.	
130.	6-in. small vertical drill, C. P. R.	5
131.	6-in. small vertical drill, C. P. R.	
132.	6-in. small vertical drill, C. P. R.	
133.	8-in. small vertical drill, W. F. & T. Barnes Company	
134.	16-in. sliding head drill press, Hamilton Machine Tool Company.	
135.	16-in. sliding head drill press, Hamilton Machine Tool Company.	
138.	2-in. 6-spindle nut tapper, Acme Machine Company	
139.	2-in. 6-spindle nut tapper, Acme Machine Company	
140.	1½-in. 6-spindle nut tapper, Acme Machine Company	
141.	1-in. 6-spindle nut tapper, Acme Machine Company	10
142.	1½-in. 4-spindle nut tapper	
143.	1-in. 4-spindle nut tapper	
144.	1½-in. 6-spindle nut tapper	
145.	1½-in. 6-spindle nut tapper	
146.	1¼-in. double bolt threader	
147.	1½-in. double bolt threader	
148.	1¼-in. double bolt threader, A. R. Williams Machine Company	10
149.	1¼-in. double bolt threader	
150.	1¼-in. triple bolt threader, Bertram & Sons	
151.	1¼-in. triple bolt threader, Bertram & Sons	
152.	1¼-in. double bolt threader, National Machine Company	
153.	2-in. triple bolt threader, National Machine Company	
154.	1-in. double bolt threader	
155.	1¼-in. double bolt threader, National Machine Company	
156.	2-in. triple bolt threader, Bertram & Sons	10
157.	2-in. triple bolt threader, Bertram & Sons	
158.	Drill grinder, Washburn Shops	
159.	Universal milling machine, No. 3, Cincinnati Milling Machine Company	
160.	Universal tool grinder, Cincinnati Milling Machine Company	

put of this shop may be gained from the fact that the store orders amount to more than the requirements at the Angus shops.

Three things are necessary to get the maximum output from a machine; a good machine; a good operator and good surroundings, including facilities for handling the work and for the comfort and convenience of the operators. Apparently all three of these have been given special attention. The machine tools are kept in an excellent state of repair; the material is handled in a neat and orderly manner; special facilities are provided for handling the work to and from the machines and clamping it in place; the operator's comfort and convenience have been studied and provided for. These features may best be emphasized by reference to the accompanying photographs.

The plan of that part of the shop in which most of the freight car parts are finished is shown in Fig. 31. Entering the door from the midway attention is first directed to the group of six-spindle drills, two of which are used entirely for drilling arch bars. One of the arch bar drills is shown in Fig. 32. Provision has been made for conducting the lubricating compound to a well from which it is circulated by a pump. The plank fastened to the front of the machine prevents the compound from splashing on the feet of the operator. In addition to this, and to prevent the compound gathering where the operator will be forced to step into it, a platform has been constructed as shown. Such of the compound or cuttings as may fall in front of the machine drop through the grating out of the way. The machine is provided with special facilities for quickly clamping the bars in place, as shown. Fig. 33 shows an arrangement which is used in connection with the drilling of steel wheel centres for passenger car work. The lubricating compound is drawn off through the funnels and drains to a well underneath, the same kind of floor for keeping the operator's feet dry being provided, as described above. A crane swings over this machine for hoisting the centres into place and they are held in a jig and drilled to template.

Provision for keeping the operators' feet dry and keeping the cuttings from under their feet has been made not only for the large machines, but also for the smaller ones, as shown in Fig. 34. The arrangement of this machine is similar to that of the other small drill presses and sensitive drills. The drill illustrated is used for drilling the cotter pin holes in brake beams. The pins are delivered from the blacksmith shop in boxes, shown alongside the machine, and the operator fills an empty box with the finished pins as he empties one of the others. That the provision for the men's comfort is appreciated is shown by the fact that they are careful to keep these features in good condition and repair.

In many of the iron freight car parts the holes are punched in the smith shop, but when they must be made to take pins, as in the brake lever jaws, etc., it is necessary to drill or ream them; there are also places where it is impossible to punch the holes. Usually the drills are fitted with clamping devices for holding the pieces so that the piece may be released or fastened in place with the tap of a hammer or pulling a lever. A jig for drilling the dead lever guides is fitted with a spacing device, the guide being shifted the proper distance between the holes by pulling a lever, marking off being thus made unnecessary.

Fig. 35 shows a row of nut tappers. The nuts are brought in from the blacksmith shop in the boxes, and as they are tapped they are dropped into a slide which carries them to the buckets back of the machines. The capacity of these buckets is just equal to that of one of the boxes. The machine in the foreground has not been equipped in this way, it being necessary for the operator to drop the nuts in the buckets in front of the machine. The other machines are, however, equipped in the same way as the one shown to the right. The boxes are weighed by a storehouse representative, and those which are to be shipped to outside points have covers nailed on them and are sent to the storehouse. Here also are seen the special platforms for keeping the operators' feet dry, the compound being drained off into wells underneath the machines.

locks, are locked at the top and have openings at the bottom, as shown in Fig. 70, from which the material is removed. Seven hundred kegs of nails may be stored in these bins. The lumber when it is brought into the shop is piled in U-shaped cradles. It does not have to be piled as carefully in this way, thus saving more or less time.

As noted at the beginning of this article, 28 standard 60-ton box cars have been regularly turned out in a day of ten hours with a force of about 200 men, or fifty men to a gang. In addition one man mixes the oil and waste for packing; one man packs all the boxes; there are six men in the pipe gang; one man looks after the bolts, etc.; there are four sweepers or cleaners; thirteen men are required to bring in the timber, which approximates 125,000 ft. per day. The general foreman, Mr. Hailey, has two assistant foremen in this shop.

The castings, draft springs, metal roofing, etc., are stored outside the shop and the rods are stored in bins similar to those illustrated in Fig. 38. Some of the material, outside the north side of the shop, mostly roofing, is shown in Fig. 71. The workmen are required to bring in the castings and roofing material which they use.

Painting.

The sliding doors between the freight car shop and the paint shop are shown in Fig. 70. The cars are pulled into the paint shop by the motor driven winches which are also partly shown in this view. The paint shop is 321 ft. long and contains 6 longitudinal tracks.

The cars are painted with spraying machines which were developed at these shops. Six men are required for this work and six for stenciling. Two coats of paint are applied and the cars are usually completed by the second evening after their erection. One man gives all his time to mixing and issuing the paint. This is done in a small addition to the freight car shop, the packing being handled in the same place.

A side view of the paint shop building, also the freight car shop, is shown in Fig. 72.

Inspecting and Weighing.

One man, who reports directly to the general foreman of the freight car department, inspects the cars carefully and sees that they are turned out in first-class condition. The finished car is shown in Fig. 73. One day's output, ready to be pulled out and weighed on the scale, shown northeast of the paint shop on the general plan, is shown in Fig. 74.

We gratefully acknowledge indebtedness for information and courtesies to the officers and men of the car department.

CAR STATISTICS.—Bulletin No. 14 of the American Railway Association, Committee on Car Efficiency gives some very interesting information concerning car performances for the month of August, 1907. While this information is given for each individual road a recapitulation for the whole country is included and shows conditions during that month to have produced the following results:

Total cars in service	2,060,066
Per cent. of home cars on line	62
Per cent. of cars in shop	6.21
Number of cars on line per freight locomotive owned	65
Average miles per car per day	24.1
Per cent. loaded mileage	70.8
Average tonnage	14.6
Average tonnage per loaded car	20.8
Average ton miles per car per day	351
Daily earnings per car owned	$8.59
Average earnings of cars on line per day	$8.44

To succeed is to study and when one quits studying his business he should at that time make up his mind that he attained his limit of success and the next change for him is a start on the "toboggan" just as sure as day follows night. This applies to the engineman who cannot be shown as well as to all others in the organization.—*Mr. R. MacBain before the Traveling Engineers' Association.*

TESTING MACHINE FOR AUTOMOBILES.

There has recently been put into operation at the New York Club House of the Automobile Club of America a very interesting machine for accurately testing all of the more important features of automobile operation. This machine will accurately indicate the speed of a car, the tractive effort in pounds, the horse-power which is being delivered at the contact of the rear wheels, the grade in per cent. or feet which the car could climb at this speed, the inclination on which the brakes would hold the car, the internal friction of the car or engine and other similar information. The whole apparatus, which in principle is modeled somewhat after a locomotive testing plant, was designed by Dr. S. S. Wheeler, vice-president of the club and president of the Crocker-Wheeler Company. Many features of the absorbing and recording instruments are entirely original and most interesting.

The general features of the dynamometer are shown in the illustrations, and in brief consist of two large wheels, on which the driving wheels of the automobile rest, mounted on a shaft supported below the floor and having their upper edges projecting above the floor level. This shaft connects through a clutch to an Alden friction brake, which absorbs the power from the shaft by transferring it to the movement of a huge pendulum, which is seen hanging from the shaft at the left in the lower illustration. The movement of this pendulum from the vertical is an accurate indication of the amount of power absorbed by the friction brake and is recorded in pounds by a pointer on the scale shown on the extreme left in the upper illustration, this scale being laid off proportional to the sine of the angle at which the pendulum is swung from the vertical. The speed of cars is recorded directly from the dynamometer shaft, allowance being made for the difference in diameter of the wheels, by a very ingenuous instrument which will be described.

One of the most valuable features of this plant is the transferring of these speed and tractive effort readings to a large chart directly in front of the car being tested. This chart, as can be seen in the illustration, has vertical scales showing the speed in any desired unit and horizontal scales showing the tractive effort in pounds. The cross rulers, giving these indications, are operated by cables, whose movement is controlled by electric motors. These motors are operated through electric contact devices so as to closely follow the movement of the pointer showing the tractive effort and transfer the reading accurately to the large scale, and also from the speed meter to the large scale. This construction is so accurate that the slightest variation in either is instantly followed by change in position of the ruler on the large chart.

The transferring of the record of the speed to the cross ruler on the chart is accomplished by a special apparatus of considerable novelty. This is shown as located in the left foreground of the upper illustration and consists primarily of a cone which is revolved at absolutely constant speed by an electric motor. This speed is verified by a bell attached to the cone shaft, which rings at each 100 revolutions or at intervals of 30 seconds, since the cone revolves at 200 r.p.m. The speed of the dynamometer shaft is transferred by shafts and bevel gears to a shaft parallel to the surface of the cone. A wheel or roller is driven by a light frictional connection to this shaft, being so arranged that it has a free movement along the shaft and tends to revolve at the same speed. The circumference of the wheel, however, rests against the surface of the cone with sufficient pressure to cause it to revolve at the same speed as that particular part of the cone with which it is in contact. This causes a slipping in its connection to the shaft which brings electric contacts into action and starts a small motor. This motor by a cable connection pulls the wheel along the shaft until it finds a point on the cone which will cause it to revolve at the same speed as the shaft. When that condition is attained the motor controlling its movement is held idle, but any change in the speed which will permit a slip in either direction will again put the motor in operation and change the location of the roller to a new position on the cone. The horizontal movement of this wheel is transferred by the same cables to the horizontal ruler on the big chart.

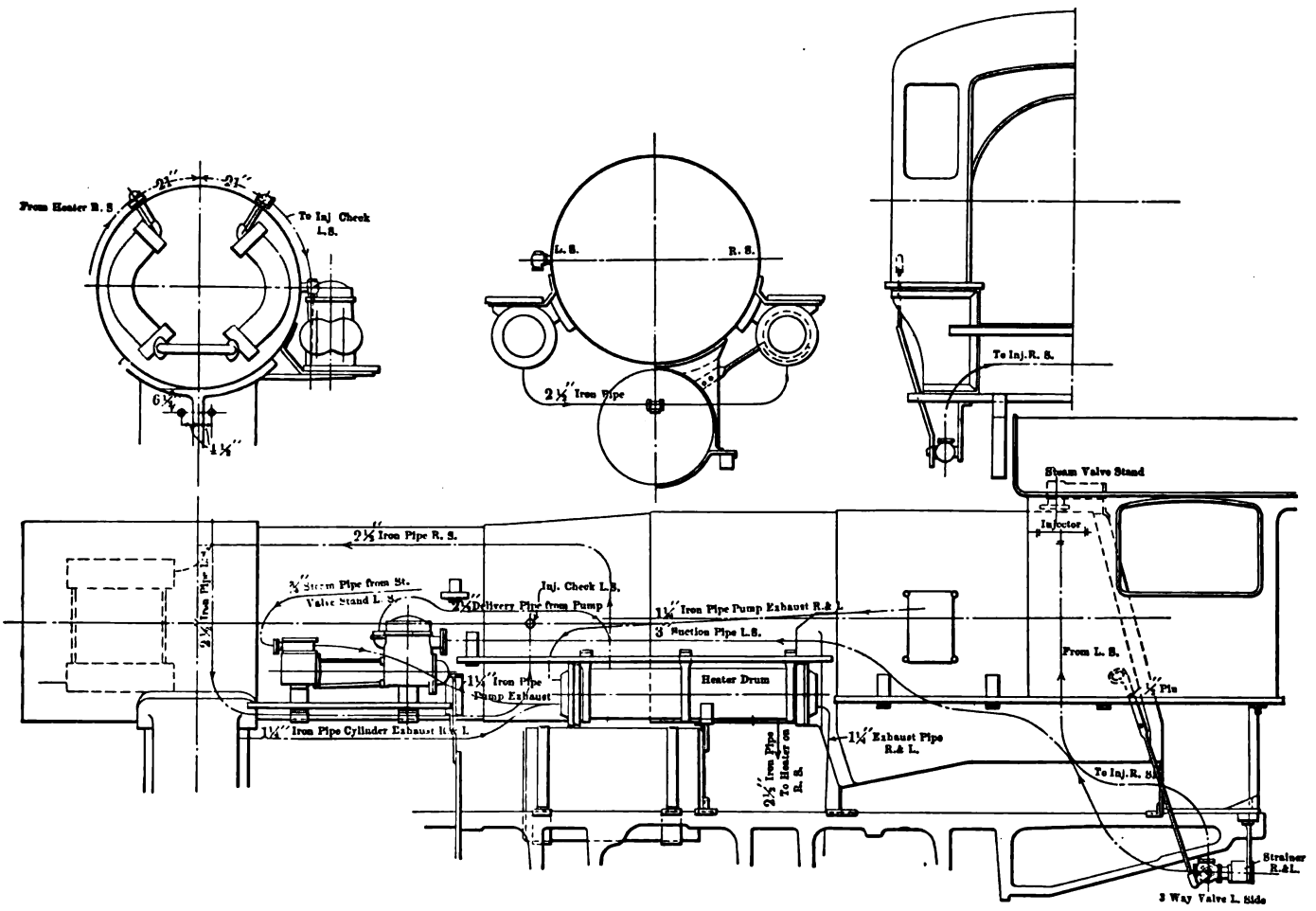
CONSOLIDATION LOCOMOTIVE WITH FEED WATER HEATER—CENTRAL OF GEORGIA RAILWAY.

LOCOMOTIVE FEED WATER HEATER.

CENTRAL OF GEORGIA RAILWAY.

It is generally admitted, by those who have made a study of the subject, that the enormous internal strains caused by the injection of comparatively cold water into a locomotive boiler are responsible for a large part of the universal difficulty that has been experienced with keeping the modern large sized locomotive boilers from leaking. Experiments with devices for more thoroughly mixing the entering supply with the water already in the boiler have resulted in much improvement in this respect, but it is easily understood that to completely overcome trouble it would be simply a matter of heating the feed water to a temperature approximately that of the water already in the boiler, so that when it is admitted there will be but a slight difference in temperature and no local distortion in the plates. It is also easy to understand that whatever heat is put into the feed water before it enters the boiler will not have to be provided later from the fire-box. This, of course, provided the heat is obtained from waste sources, results in either less coal required to furnish the same amount of steam, or a larger boiler capacity with the same amount of coal burned.

These advantages have been given more practical attention in those countries where the cost of fuel is very high, and where any device seeming to insure fuel economy has always been given



LOCOMOTIVE FEED WATER HEATER SHOWING COURSE FOLLOWED BY THE WATER.

quired in the main members for a coach to operate under the conditions for which we have previously noted this form was most useful. That is for a road which handles passenger electric multiple control trains exclusively with schedule speeds of not more than 45 miles per hour and the maximum trains run in either express or local service to be of eight cars. The weight of these cars to be 70,000 pounds for trailers and 75,000 pounds for motors of approximately 52 feet long over platform and end sills.

In this exposition we aim to show how to use the loads to find the stresses for any car of this form, and as a consequence we shall not take into account the possibility of future developments in operation of the road. These developments would not change the character of the strains but they would alter their intensity. The degree of such change fluctuates with so many variables, as before noted, that a consideration of them would not help the discussion of how strains of this character are resisted and the stress in the members produced by such resistance. The local trains weigh more than the express trains in this service for the reason that the proportion of motor cars to trailer cars must be increased so as to obtain sufficient acceleration to make time with the very frequent stops required. The express trains travel with greater schedule speed and from an examination of such trains on existing lines we find that the kinetic energy of the two trains is about equal and that of a local excursion train of double the number of cars is not much in excess of the value of the express.

The kinetic energies of the heavy steam express trains on several prominent trunk lines operating at schedule speeds ranges anywhere from 50,000,000 to 120,000,000 foot-pounds, for which trains we have advocated a shock of 500,000 pounds static for buffing.

The kinetic energy inherent in an eight motor car train operating between 40 and 45 miles per hour is about 50,000,000 foot-pounds. The factors of weight and speed having been taken into account in both steam and electric service and the short headway in the latter making for as much possibility of operating accidents as are pregnant in the former, it would seem proper to assume that the end shocks that should be provided for in the latter case would be 5/12 of 500,000, which is about 200,000 pounds. This will illustrate exactly what is meant by the relative value of the quality of reliability, and other conditions being equal the end shocks may safely be assumed to vary from 0 to a maximum of 500,000 pounds (recommended from Lake Shore tests), and that the degree of end shock be chosen according to the ratio of kinetic energies.

ARRANGEMENT OF UNDERFRAME MEMBERS.

The diagram, Fig. 1, illustrates the disposition of the members of the framing but does not represent our ideas of detail design to stand up under the assumed end shock.

The centre sills are composed of shallow I-beams, the largest and heaviest section for the 6-inch beam being assumed. They are to be continuous from platform to platform and rest upon transverse supports to the side girder. The body end sill is the first support, next would come the bolster and between the two bolsters these supports are placed at the main posts, which in turn are spaced according to the window arrangement most convenient to the passengers and character of seating. The centre sills are then a continuous beam with 10 spans. The character of the end construction determines the values of bending stresses in the last span at each end and affects the moment in the spans contiguous to them. If the vestibule is made strong enough in the hood to act as a cantilever to help support the platform, then the end sills in this region are loaded with a uniform load, which is a maximum when the car is filling up or emptying and the platform is full of passengers. Opposed to this design is that in which the end sills get half the platform load at the platform end sill; this will increase the end bending moment in the end spans. In the former case the end span is supported and in the latter is overhanging. The supported end is the best condition and to secure it the end roof construction must be designed for good vertical rigidity and stiffness. This will in effect transfer all this load to the side girder through the body end construction and end sills. There is no other way to take care of it and provide for platform doors and steps. The diagram does not show steps, but their use is necessary for nearly all service conditions.

Centre Sill Lading.—The character of the loading which comes on these beams is a combination of, first, the uniform lading due to dead weight and passenger lading, and, second, that from the uniform load, equivalent in effect to the end shock or, if no end shock is to be provided for, the eccentric tension or compression due to the motor torque.

The determination of the reactions at the supports or transverse beams are not readily found in this type of beam (continuous) and difficulties are interposed to the finding of the shearing stresses and moments at the various sections which should be investigated. A positive check upon all the theory connected with these sills is afforded by an application of the general principles of the equation of equilibrium between external and internal forces and moments. These fundamental theories must hold as well as those for shear and moments. Stated concisely these are, *"that for any section the shearing stresses and moments are respectively equal to the algebraic loads and moments on either side of that section."* It is customary to consider the left side in calculating. Not only do these afford a check, but they are used to find the general formulæ applicable to any given case.

Each mid-span of this girder is in the same condition as if it had both of its ends overhanging and the two end spans at the platforms with but one end overhanging (for the supported condition, otherwise it would be in the position of a beam with a support in the central region).

Using a standard structural shape for the centre sills with a constant cross section and depth, the values of moment of inertia and modulus of resistance are equal throughout the sills if the supports are at the same level. This simplifies the application of the theory of three moments to the case in hand. The question as to whether it is advisable to use a light box girder of the same weight as two simple rolled shapes will depend to a great extent upon the character of the climate and atmosphere where the cars are intended to run. With the strength disposed in such a manner all the members are very thin and a corrosive atmosphere will shortly seriously impair their usefulness, since a small amount of corrosion represents such a large loss of percentage area and strength. No matter what the character of the lading or the form of the beam the theorem of "three moments" will apply to it.

THEORETICAL DISCUSSION OF CENTRE SILLS.

Continuous Beams.—The treatment of this theorem is very unsatisfactory in the majority of text and reference books upon the "Mechanics of Materials" and "Girder Design." The lack is due to the fact that with few exceptions the only beams treated are for uniform loads and lengths for all spans, so that the application to any special beam other than found therein requires the working out of a suitable formula to suit it. The derivation of the completed general formula will be found for the centre sill assumed, and the remainder written by analogy to fit each span.

The method of the solution is to first find the equation of the elastic curves for any section and its adjacent span which multiplied by the product of the coefficient of elasticity into the moment of inertia will be a measure of the bending moment. These two differential equations when integrated once and the constants of integration determined represent the slope of the tangent to the elastic curve. Now since the curves have been found for two adjacent spans it follows that over the point of support between the spans the curves must have a common tangent. The next step is to evaluate the tangent equations for the ordinates of this point of tangency and equate the two equations which are now identical and the solution of this resulting equation gives a result showing the relation between the three moments, the two span lengths and the loading upon each length. The problem is complicated somewhat because the equations contain

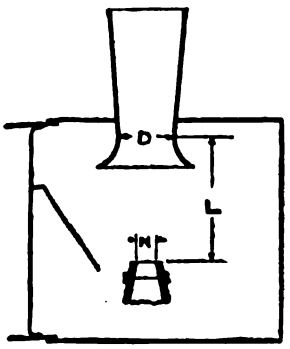


FIG. 10.

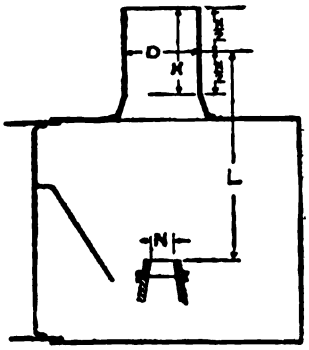


FIG. 11.

report for plain front ends, Series No. 2 to No. 9.

From these diagrams Table II. and Fig. 10 have been taken.

TABLE II.

Series.	"D" Best Results.	L.	L.	D / 5 11/16 √L
2	Greater than 21"	66"		
3	23"	66"	8.12	.497
4	Greater than 21"	66"		
5	19"	53½"	7.32	.456
6	19"	41½"	6.44	.518
7	16"	29½"	5.43	.517
8	17"	41½"	6.44	.464
9	16"	29½"	5.43	.517
Average				.49

The equation for these tests is then $D = .49\ N\ \sqrt{L}$, derived in the same manner as for the 1903 tests. Referring again to the tests of 1896, the equation derived similarly is $D = .48\ \sqrt{L}$. The larger constant in the formula for the 1906 tests is probably due to the form of the nozzle. The 1903 nozzle is like Style "X," shown in the 1896 report, while the 1906 nozzle is like Style "Y"; Style "X," as stated in the 1896 report, gives less spread to the jet and would, therefore, require a slightly smaller stack than Style "Y."

The close agreement between the equations for the three years would seem to be sufficient proof of the reliability of the formula for general use.

Fig. 12 shows a diagram for conveniently finding the diameter of choke for taper stacks, based on the equation $D = .49\ N\ \sqrt{L}$.

STRAIGHT STACKS.

It is reasonable to suppose that the formula for straight stacks would be similar to that for taper stacks. In this case there is no definite place corresponding to the choke of a taper stack which may be taken as a measuring point.

Table III. and Fig. 11, however, show the results for the tests of 1903, obtained by taking "L" to the middle of the straight portion of the straight stacks and would seem to indicate that the formula $D = .49\ \sqrt{L}$ would give satisfactory results for straight stacks also.

TABLE III.

Length of Stack.	Nozzle Number.	"D" Best Results.	L.	√L.	D / 4¼ √L.
26½"	1	Greater than 15¾"	60		
	2	15¾"	55	7.42	.500
	3	14¼"	50	7.07	.474
	4	13¾"	45	6.71	.483
	5	13¼"	40	6.32	.493
	6	12¾"	35	5.92	.487
	7	11¾"	30	5.48	.503
36½"	1	Greater than 15¾"	65		
	2	Greater than 15¾"	60		
	3	15¾"	55	7.42	.500
	4	14¾"	50	7.07	.491
	5	14¼"	45	6.71	.500
	6	13¾"	40	6.32	.493
	7	11¾"	35	5.92	.467
46½"	1	Greater than 15¾"	70		
	2	Greater than 15¾"	65		
	3	Greater than 15¾"	60		
	4	15¾"	55	7.42	.484
	5	14¾"	50	7.07	.491
	6	14¼"	45	6.71	.500
	7	13¾"	40	6.32	.493
56½"	1	Greater than 15¾"	75		
	2	Greater than 15¾"	70		
	3	Greater than 15¾"	65		
	4	15¾"	60	7.75	.478
	5	15¾"	55	7.42	.500
	6	14¾"	50	7.07	.491
	7	13¾"	45	6.71	.483
Average					.49

Inasmuch as the variation in diameter of the stack is from two and a half to four times the variation in nozzle diameter, considerable care will be necessary in using this formula on new designs to determine the diameter of the nozzle reasonably close in advance for the particular conditions under which the engine is to operate. On old engines, the problem is simple, of course, as the size of the nozzle can be measured readily and the stack diameter can be taken from Fig. 12.

It should be noted that this formula is based on front ends without draft pipes and, therefore, as determined by the Master Mechanics' Committee in 1906, will give larger stack diameters than for front ends with draft pipes, this being in accordance with their report, that the larger stack without draft pipes gave the most satisfactory results.

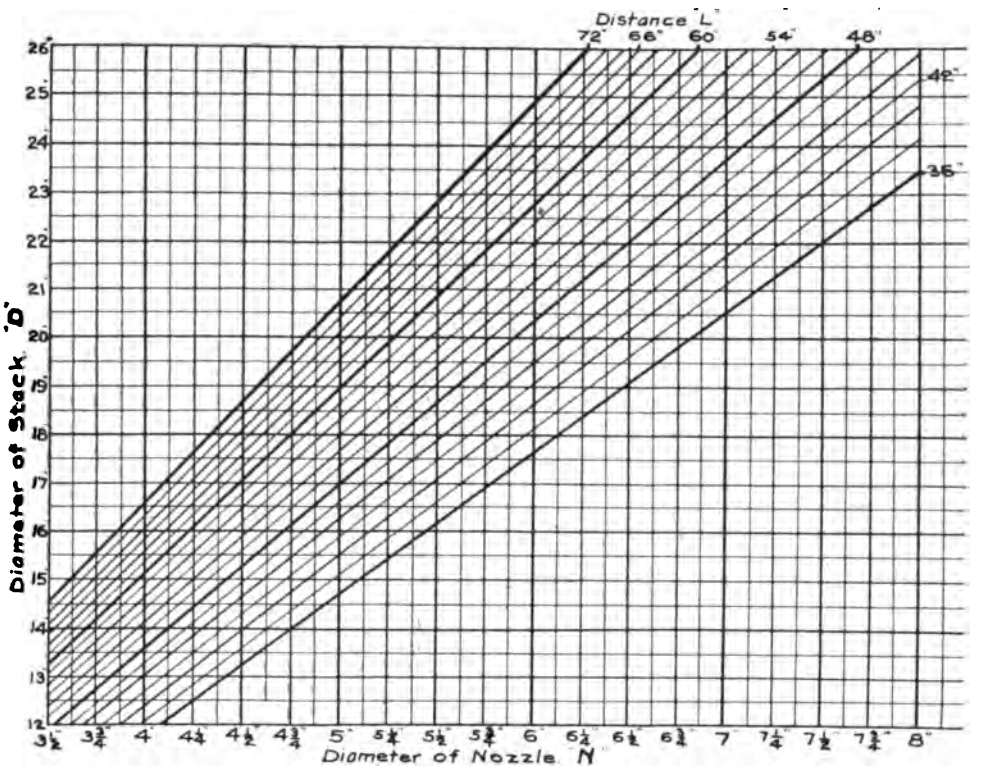


FIG. 12.

REQUIREMENTS OF SUCCESSFUL TRAVELING ENGINEERS.—Success and skill as enginemen are not all that is essential in a road foreman or traveling engineer—good judgment, a cool head, a temperate tongue and a "thick skin" are perhaps the best assets he can have. Without these he is not likely to possess the art of "approaching" in a satisfactory manner, the rank and file of enginemen with their various dispositions.—*Mr. D. R. MacBain before the Traveling Engineers' Association.*

LONGEST RAILWAY BRIDGE.—There is now in process of construction at Vancouver, Washington, a bridge to carry the Seattle, Portland Railway Company's line across the Columbia River, which when completed will have the distinction of being the longest bridge of its class in the world. Its total length will be 1½ miles and its width will be about 35 ft., carrying a double track. The completed bridge will comprise 47 spans. A draw span, 450 ft. long, is provided in the centre of the river.

at the company's shops, including cost of transportation and setting up after receipt from builders.

38. ELECTRIC LOCOMOTIVES.—To this account should be charged the cost of electric locomotives, *including all appurtenances, furniture, and fixtures necessary to equip them for service,* purchased or built at the company's shops, including cost of transportation and setting up after receipt from builders.

(The following extracts are taken from the "Classification of Operating Expenses, as Prescribed by the Interstate Commerce Commission, in Accordance with Section 20 of The Act to Regulate Commerce, "Third Revised Issue"):

[*From Page* 18.]

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IV.	TRANSPORTATION EXPENSES—	
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(Numbers in brackets refer to consecutive arrangement of Primary Accounts as listed on pages 17 to 20, inclusive, of the "Classification of Operating Expenses as Prescribed by the Interstate Commerce Commission in Accordance with Section 20 of The Act to Regulate Commerce—"Third Revised Issue—1907.")

[*From Pages* 42 *and* 43.]

STEAM LOCOMOTIVES—REPAIRS.

This account includes cost of material used (less salvage) and labor expended in repairing steam locomotives and tenders, and *fixtures thereof (except as otherwise provided for); such as air signal equipment, including hose, arm rests, awnings,* brake fixtures, *cab and steam-gage lamps, cab cushions, clocks, coal boards, fire extinguishers permanently attached to locomotives, gongs, head lamps,* pneumatic sanding equipment, *seat boxes, speed recorders,* steam and other power brakes, *steam-heat appliances, including hose and all other appliances of like nature, storm doors, tool boxes;* also cost of supervision; *pay of locomotive inspectors engaged in inspecting all parts of locomotives and tenders* (except pay of smokestack and ash-pan inspectors, which should be charged to account "Enginehouse Expenses—Yard" or "Enginehouse Expenses—Road"), pay of employees engaged in sponging tender, driving and truck boxes of locomotives undergoing repairs in shops (but pay of employees similarly engaged on locomotives not undergoing repairs in shops should be charged to account "Enginehouse Expenses—Yard" or "Enginehouse Expenses—Road"), and cost of cutting up condemned locomotives and tenders; small hand tools used exclusively in locomotive repairs; special service, such as bringing locomotives to shops or watching them while on the way to shops for repairs, and trying locomotives after having been repaired; traveling expenses of employees whose pay is chargeable to this account; and payments of royalties, or for patent rights on brakes, brake fixtures, and other appliances used on locomotives; also proportion of shop expenses as provided in Note following account "Other Expenses."

The value of old material released during repairs and insurance recovered should be credited to this account.

Note A.—The word "repairs" as here used *includes all repairs on or renewals of parts of locomotives and tenders commonly known as steam-locomotive fixtures or attachments,* and classified as running or roundhouse repairs; *also repairs to or renewals* of the more important or vital parts of locomotives and tenders, the necessity for which is *caused by breakage, failure, or accident while in service;* also the repairs to a steam locomotive or tender damaged through accident or otherwise, necessary to restore it to service; and also renewal of important or vital parts made necessary by reason of age or wear and tear from use.

Note B.—The cost of repairing steam locomotives and tenders of foreign lines wayhilled as freight, damaged in transit, should be charged to account "Loss and Damage—Freight," and the cost of repairing steam locomotives of foreign lines having trackage rights over a carrier's line damaged in collision or wreck for which a carrier is liable should be charged to account "Damage to Property."

[*From Page* 68.]

ENGINEHOUSE EXPENSES—YARD.

This account includes *pay of, and cost of supplies furnished* to callers, watchmen, and other *employees* engaged in wiping, cleaning, firing up, *dumping, boiler washing,* cleaning fire boxes, watching, and dispatching locomotives; and of other enginehouse employees, such as *tool checkers,* enginehouse cleaners, *cinder pit cleaners,* clinker dumpers, truck packers, turntable operators, *sand dryers,* inspectors of smokestacks and ash pans, when engaged in caring for locomotives in yard or terminal service; also a proportion of wages paid enginehouse foremen and their clerks.

Some of the more important items chargeable to this account are: *Boiled oil, lampblack, rags, waste, lye, cleaning and polishing compounds, tools for truck packers and hostlers, signal lights on turntabes and transfer tables at enginehouses,* expenses of operation of such tables by power; heating and lighting enginehouses and offices in them; oil for lubricating turntables; *shovels, wheelbarrows, and other tools for cleaning around enginehouses and handling cinders;* rent of cinder cars used at cinder pits; *hose* and water *for cinder pits and for washing out boilers,* cupboards in enginehouses, mechanical blowers and fire lighters for starting locomotive fires.

Note.—When enginehouse expenses are incurred jointly for yard and road locomotives they should be apportioned on basis of number of locomotives of each class handled.

[*From Page* 69.]

OTHER SUPPLIES FOR YARD LOCOMOTIVES.

This account includes the cost of *headlight and signal oil and wicks used in headlights, signal lights, and enginemen's torches; supplies for electric-light dynamos and carbide for acetylene gas for lights on locomotives in yard service,* also the *cost of furniture, tools, and other movable articles and supplies required fully to equip yard locomotives for service.*

[*From Page* 70.]

The following are some of the items chargeable to this account, when furnished for use of yard enginemen:

Ash hoes,	*Hose (not air brake, air signal, or steam),*	*Saws,*
Ash-pan rods,	*Hose reels,*	*Scoops,*
Axes,	*Jacks,*	*Shovels,*
Bars, buggy,	*Jackscrews,*	*Slash bars,*
Bell cords,	*Lamps (signal only),*	*Sledges,*
Boxes (portable),	*Lanterns and parts,*	*Soap,*
Brooms,	*Locks for Portable boxes,*	*Switch chains,*
Brushes,	*Matches,*	*Switch ropes,*
Buckets,	*Metallic packing,*	*Switch poles,*
Chimneys, headlights,	*Oilers,*	*Thaw-out hose,*
Chisels,	*Oil cans,*	*Tool boxes (portable),*
Clinker hooks,	*Packing hooks,*	*Torches,*
Crowbars,	*Packing spoons,*	*Torpedoes,*
Files,	*Picks,*	*Water buckets,*
Flags,	*Pinch bars,*	*Water coolers,*
Grate shakers,	*Plugging bars,*	*Wrecking frogs,*
Hammers,	*Pokers,*	*Wrenches.*
Handsaws,		
Hatchets,		

Note.—For cost of sand, see account "Other Supplies for Road Locomotives."

[*From Pages* 71 *and* 72.]

ENGINEHOUSE EXPENSES—ROAD.

This account includes *pay of and supplies furnished* to callers, watchmen, and other *employees* engaged in wiping, cleaning, firing up, *dumping, boiler washing,* cleaning fire boxes, watching, and dispatching locomotives; and of other enginehouse employees, such as *tool checkers,* enginehouse cleaners, *cinder pit cleaners,* clinker dumpers, truck packers, turntable operators, *sand dryers,* inspectors of smokestacks and ash pans, when engaged in caring for locomotives in road service; also a proportion of wages paid enginehouse foremen and their clerks.

Some of the more important items chargeable to this account are: *Boiled oil, lampblack, rags, waste, lye, cleaning and polishing compounds, tools for truck packers and hostlers, signal lights on turntables and transfer tables at enginehouses,* expense of operation of such tables by power, heating, and lighting enginehouses and offices in them, oil for lubricating turntables, *shovels, wheelbarrows, and other tools for cleaning around enginehouses and handling cinders;* rent of cinder cars used at cinder pits; *hose* and water *for cinder pits and for washing out boilers;* cupboards in enginehouses, mechanical blowers and fire lighters for starting locomotive fires.

Note A.—When enginehouse expenses are incurred jointly for yard and road locomotives, they should be apportioned on basis of number of locomotives handled.

Note B.—Cost of enginehouse expenses on locomotives engaged in work-train service should be charged as a part of work on which engaged.

[*From Page* 73.]

OTHER SUPPLIES FOR ROAD LOCOMOTIVES.

This account includes the cost of *headlight and signal oil and wicks used in headlights, signal lights, and enginemen's torches; supplies for electric light dynamos and carbide for acetylene gas for lights on locomotives in road service;* also the *cost of furniture, tools and other movable articles and supplies required fully to equip road locomotives for service; fuel for sand dryers and cost of sand and of loading it at sand pits; wheelbarrows, shovels, and sand screens used in handling sand for road locomotives.*

The following are some of the more important items chargeable to this account:

Ash hoes,	*Hose (not air brake, air signal, or steam),*	*Sand,*
Ash-pan rods,	*Hose reels,*	*Saws,*
Axes,	*Jacks,*	*Scoops,*
Bars, buggy,	*Jackscrews,*	*Shovels,*
Bell cords,	*Lamps (signal only),*	*Slash bars,*
Boxes (portable),	*Lanterns and parts,*	*Sledges,*
Brooms,	*Locks for Portable boxes,*	*Soap,*
Brushes,	*Matches,*	*Switch chains,*
Buckets,	*Metallic packing,*	*Switch ropes,*
Chimneys (headlight),	*Oilers,*	*Switch poles,*
Chisels,	*Oil cans,*	*Thaw-out hose,*
Clinker hooks,	*Packing hooks,*	*Tool boxes (portable),*
Crowbars,	*Packing spoons,*	*Torches,*
Files,	*Picks,*	*Torpedoes,*
Flags,	*Pinch bars,*	*Water buckets,*
Grate shakers,	*Plugging bars,*	*Water coolers,*
Hammers,	*Pokers,*	*Wrecking frogs,*
Handsaws,		*Wrenches.*
Hatchets,		

Note A.—Cost of other supplies for locomotives engaged in work-train service should be charged as a part of the work on which engaged.

Note B.—The cost of sand as between yard and road locomotives being undetermined, the entire cost of sand issued to all locomotives should be charged to this account.

The Interstate Commerce Commission prescribed accounts are the basis of our records—legally must be the basis. Those portions of them relating at all to locomotive supplies and equipments, and the handling of these supplies, etc., have been quoted in extenso, verbatim. For the purpose of seeing more clearly the items included in this mass of text, let us rearrange them in list form, and omit all text not strictly relevant to the supplies or their handling expense. There follows such an arrangement.

NEW LOCOMOTIVES—STEAM AND ELECTRIC.

Appurtenances, Furniture and Fixtures.

LOCOMOTIVE REPAIRS—STEAM AND ELECTRIC.

Material (less salvage); labor; fixtures; air signal equipment including hose; arm rests; awnings; cab and steam-gage lamps; cab cushions; clocks; coal boards; fire extinguishers permanently attached; gongs; head lamps; seat boxes; speed recorders; steam heat appliances including hose and appliances of like nature; storm doors; tool boxes; also supervision; locomotive inspectors; repairs on or removals of parts of locomotives and tenders, known as fixtures or attachments, caused by breakage, failure or accident.

ENGINEHOUSE EXPENSES—YARD AND ROAD.

Pay of and supplies furnished to employees; dumping; boiler washing; tool checkers and sand dryers; boiled oil; lampblack; rags; waste; lye; cleaning and polishing compounds; tools for truck packers and hostlers; signal lights on turntables; shovels; wheelbarrows; tools for cleaning around enginehouses and handling cinders; hose for cinder pits and for washing out boilers; cupboards in enginehouse.

OTHER SUPPLIES AND OIL FOR LOCOMOTIVES—YARD AND ROAD.

Headlight and signal oil and wicks; supplies for electric light dynamos carbide for acetylene gas; furniture; tools; movable articles and sup-

(Established 1832).

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Contributions.—*Articles relating to Motive Power Department problems, including the design, construction, maintenance and operation of rolling stock, also of shops and roundhouses and their equipment are desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

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A resolution was passed at the last meeting of the New York Railroad Club requesting the committee on subjects of the M. C. B. Association to bring the subject of standardization of parts of all steel cars up for consideration at the convention. This resolution grew out of the recommendation in Mr. A. M. Waitt's paper, and while the suggestion is not by any means new, it appears as if the time had arrived when some real action could be taken upon it.

The desirability of such standards is being more thoroughly appreciated as steel cars are becoming more numerous. When a steel car is damaged sufficiently to require it to be sent to the repair yards of a foreign road, it usually is in a condition to need some new parts and if, as is often the case, it differs greatly from the cars on the road doing the repairing, the delay in obtaining the proper shaped and sized parts is very serious and most aggravating to all concerned.

SUPERHEATERS.

Herr Robert Garbe, privy counsellor of the Prussian State Railways, has probably had a longer and more thoroughly practical experience with locomotive superheaters than any other railway man on either continent. While his published works give in great detail the results of his observations on locomotives and locomotive appliances, a series of articles which he recently contributed to the *Engineer* (London) on the subject of the application of highly superheated steam to locomotives, presented the matter connected with superheated steam in a comparatively brief and very clear-cut manner. These articles give the author's ideas on each separate phase of the subject and briefly recount reasons for his deductions. An abstract of part of this series of articles is given in this issue for the benefit of such of our readers as do not have access to the *Engineer*.

It will be seen that Herr Garbe does not consider steam to be superheated in the real sense until it is at least 180 degrees F. above the saturation temperature for the pressure. His experience has shown that below this point there is a very rapid falling off in the advantages to be gained. The fact mentioned, that a locomotive on the Prussian State Railways with steam superheated to this temperature was capable of developing 40 per cent. more power than a similar sized saturated steam compound locomotive, which power was obtained with 10 per cent. less fuel consumption, is a feature which is worthy of the most careful consideration.

DESIGN OF WALSCHAERT VALVE GEAR.

The Walschaert valve gear has passed through its trial period in this country and is now being generally applied to all middle and heavy weight power. There is no need to recount its advantages, as they are now too well known to every one to require comment. There is need, however, for our locomotive designers and draftsmen to give special heed to the details of this gear, as they will no doubt be required to design it for application to practically all types of locomotives.

As is natural in applying an entirely new arrangement, the first attempts left considerable to be desired. Although the Walschaert valve gear had been in use abroad for a great many years, and its details there have been fully perfected, that fact proved to be of small value to us and the first attempts, based largely on foreign practice, were not altogether suited to our conditions. It has been necessary to strengthen, stiffen and simplify each successive application as the weak points have been developed by the very hard service under American conditions, intensified by serious traffic congestion. We believe now, however, that this period has passed and the present designs of this gear being applied have eliminated all of the serious shortcomings and can safely be taken as a basis and guide for the evolving of designs in the railroad drafting rooms. In this issue we are giving most of the important details of two different designs of the gear, one from each of the larger locomotive companies, both of which we believe to be good examples. In an earlier number we gave

recommendations toward greater uniformity in sizes and greater simplicity in design.

"It seems perfectly feasible at this time to adopt as recommended practice and later as standards some rolled and pressed sections, at least in the main members of the body framing. A move in this direction would before long be felt in increased simplicity and economy in interchange repairs. It would seem even possible at this time to adopt standards in lengths and widths for steel box, gondolas and flat cars, and then as a natural sequence many standard shapes and sizes would follow. It would also be practicable to standardize many of the rolled sections for angles and channels which are used in the superstructure of many styles of cars now being constructed.

"In freight and in passenger car construction during the development period in the past the cars were strengthened where found necessary and all sorts of makeshift methods and devices, such as truss rods, flitch plates, and the introduction of malleable for cast iron were made use of. All this was done to make the car stand up in service, with their increasing size, and the increased severity of the work imposed upon them. All these expedients proved ineffectual and unsatisfactory, and at this time the needs of our present-day service can only be met by a car with a steel body framing.

"During the past year one prominent road in the country has designed and constructed box cars with not only a steel underframing but also with a steel superstructure. This is a daring attempt to further develop 'the era of steel' for car construction, but the practice is one which would seem to be open to decided doubt as to the entirely satisfactory results that will be obtained in service. On first impression the observer might assume from the description or examination of the all-steel box car that it was in every way a decided advance step. It is to be hoped that railroads will very carefully consider the history of steel box cars both abroad as well as at home before going very heavily into their construction.

"In the construction of gondolas and flat cars, except where such cars are likely to be used in service for hot cinders, hot billets, or some similar lading, it would seem to the writer the wisest policy to use a wooden flooring rather than steel.

"With now some ten years of extensive use of steel underframe and all-steel freight cars the earlier arguments in favor of their almost universal adoption have been strengthened and broadened. Even if the lumber supply was likely to be ample in the future, there can be little justification in perpetuating the wooden car, either by large continued expenditures for the maintenance of light capacity cars or by ordering cars with a wooden body framing for present or future use.

"In a paper read before the New England Railroad Club in 1904 by Mr. John H. MacEnulty, the writer stated that: 'It has been determined by two of the largest railway systems of the country that the drawbar pull required to move a ton of freight in a properly constructed car of 100,000 lbs. capacity is 24 per cent. less than that required to move the same load in an average wooden car of 60,000 pounds capacity.'

"This is not only a strong argument in favor of steel car construction, but also for the use of large capacity cars.

"Ease of renewal of the worn or broken parts in cars of steel construction is a feature of considerable advantage in favor of such cars as compared with those made of wood.

"Another great advantage from the use of steel cars or cars with steel underframe in freight service is developed when trains are wrecked; for steel cars in wrecks withstand successfully punishment which would mean the total destruction of wooden cars. It has been found that the parts bent or torn in damaged steel cars can be readily renewed or put back in their original shape at a comparatively reasonable cost.

"Wooden cars are damaged yearly in large numbers to an extent which makes them unfit for service and not worth repairing. With steel cars such a condition is practically impossible."

"The cost of steel cars per ton of hauling capacity in general is less than with wooden cars. In wooden cars of high capacity it is found that the ratio of light weight to the carrying capacity is altogether too high for comparison with steel cars, if viewed from the basis of economy in operation.

"In cost of maintenance the steel car has a decided advantage. In meeting the requirements of service in the operating department again the steel car is decidedly the favorite. Steel cars are so much less liable to damage in service that in many cases where a wooden car would be rendered unfit to continue in use, a steel car will be free from any serious defects and will continue as a money earner and not become a money loser.

"The life of wooden cars built to-day must necessarily be shorter than those built fifteen years ago, for at the present time it is impossible to get lumber anywhere approaching in quality that which was required in first-class freight cars in 1892.

"Trains are now frequently being made up containing from sixty to eighty or more heavily loaded cars, weighing from 3,000 to 4,000 tons, and the severe service and strains to which the cars are subjected make the cost of necessary repairs to the wooden cars increase constantly. On roads having such heavy traffic and handling such long trains, or whose cars are likely to be handled in such trains, they can ill afford to spend much money for the heavy repairs and maintenance of wooden freight cars of under 60,000 pounds capacity, and it is clearly no longer profitable to build such cars, which are necessarily too lightly framed to operate in conjunction with the heavy capacity steel car.

"As showing the conclusions arrived at, on one of the prominent railway systems of the country, the writer has before him the report and recommendations made to the chief executive officer of the company at a recent date. The report recommends the retiring of 4,600 coal and coke cars ranging from nine to twenty-three years in age, and having from 40,000 to 60,000 pounds capacity.

"It was shown that these cars average a cost of $95.98 per year for repairs, or 37.8 per cent. of the average total value of the cars. The tonnage of these cars being compared with tonnage of new steel cars which have been used by the company in large numbers, when considered in connection with the first cost and the cost of maintenance of steel cars, and based on experience, showed conclusively that the company could buy 3,000 new steel cars having a total capacity 20 per cent. greater than that of the 4,600 wooden cars, and out of the amount that it would cost to maintain the wooden cars for one year they could pay 6 per cent. interest on the cost price of the new steel cars and have remaining over $215,000. A desire for the greatest economy for the owners of the roads will assure the substitution of a lesser number of larger capacity steel cars for old light capacity wooden ones.

"Although steel underframing and practically all-steel construction has been used for a number of years for about all of the various types of freight equipment, yet it is only during the past three years that much has been done in this country to adapt such construction to the various styles of passenger equipment.

"Very satisfactory designs have been developed for baggage and postal cars, as well as for suburban and regular passenger service, and within the past year also for Pullman sleepers. It is yet too early to predict the outcome, but it seems to the writer that in future development of the design for steel passenger equipment cars there may be a happy medium arrived at, and generally adopted, where the underframes and the superstructure framing will be of metal, but a reasonable use be made of wood or some fireproof substitute, other than metal, which will permit of a decorative treatment that is more pleasing to the eye than is the case where thin metal is used, and which will also have all of the reasonable and necessary elements of safety for those who entrust their lives in such cars.

"In the early days of steel cars the matter of repairs was looked upon with many misgivings by the average master car builder and car repair foreman. Experience in handling these cars in large numbers has shown that there was no cause for any uneasiness on this score. In the repairs of steel cars it is not necessary to employ specially trained labor, and very few extra tools or facilities are absolutely necessary, though, of course, a

E. F. Fay, master mechanic of the Union Pacific R. R. at Denver, Colo., has been transferred to Cheyenne, Wyo., as superintendent of shops.

J. A. Doarnberger has been appointed master boiler maker of the Norfolk & Western Ry., with jurisdiction of the boiler work of the whole system.

J. G. McLaren has been appointed master mechanic of the Chicago, Rock Island & El Paso Ry., with office at Dalhart, Tex., in place of J. McDonough.

J. L. Sydnor, formerly bonus supervisor of the Coast Lines of the Santa Fe, has been transferred to Topeka as bonus supervisor of the Eastern Grand Division.

J. A. Turtle, assistant superintendent of motive power of the Union Pacific R. R., has been transferred to Denver, Colo., succeeding E. F. Fay as master mechanic.

J. F. Whiteford, general roundhouse inspector of the Santa Fe, has been appointed bonus supervisor of the Coast Lines, with headquarters at San Bernardino, Cal.

Michael Flanagan has been appointed master mechanic of the Montana division of the Great Northern Ry. at Havre, Mont., in place of K. Froburg, transferred.

G. J. DeVilbiss, superintendent of motive power of the Toledo & Ohio Central Ry., has had his jurisdiction extended to include the Marietta, Columbus & Cleveland R. R.

The office of J. S. Chambers, superintendent of motive power of the Atlantic Coast Line, has been changed from Wilmington, N. C., to South Rocky Mount, N. C.

A. Dinan, master mechanic of the Middle division of the Santa Fe, has been transferred to the Missouri division, with office at Fort Madison, Ia., in place of J. H. McGoff, promoted.

T. S. Reilly, associate editor of the *Railway and Engineering Review*, at Chicago, has resigned, to become superintendent of the mechanical department of the Canton & Hankow Railway at Canton, China.

C. F. Harding has been appointed professor of the school of electrical engineering at Purdue University. Prof. Harding comes from Cornell, where he has held the position of associate professor of electrical engineering.

Charles E. Fuller, until recently superintendent of motive power of the Chicago & Alton R. R., has been appointed assistant superintendent of motive power and machinery of the Union Pacific R. R. at Omaha, Neb.

J. P. McCuen, superintendent of motive power of the Cincinnati, New Orleans & Texas Pacific Ry., has resigned that position, effective on March 1, when he will take the rest to which he is entitled after long years of service. Mr. McCuen entered the employ of the Queen & Crescent Route as road foreman on March 1, 1882.

The master mechanics of the Atlanta, Birmingham, Knoxville and Selma divisions of the Southern Railway, have been transferred as follows: John F. Sheahan, Atlanta, Ga., transferred to Knoxville, Tenn.; J. B. Michael, Knoxville, Tenn., transferred to Selma, Ala.; G. Akans, Selma, Ala., transferred to Birmingham, Ala., and N. N. Boyden, Birmingham, Ala., transferred to Atlanta, Ga. It is reported that these changes are in accordance with a new ruling on that road which requires the transfer of all master mechanics every two years.

The New York, New Haven & Hartford R. R. has transferred master mechanics as a result of the rearrangement of divisions. The appointments and headquarters now are as follows: New York division, J. M. Collins at Harlem River; the Shore Line, P. C. Zang, at New Haven; the Providence, G. A. Moriarity, at Providence; the Boston, J. Hocking, at South Boston; Old Colony, D. R. Killinger, at Taunton; the Midland, J. B. Gannon, at East Hartford; the Western, H. C. Oviatt, at New Haven. J. McCabe, heretofore engine foreman at the Harlem River terminal, has been appointed general road foreman of engines, with headquarters at New Haven.

NOTES

REFINED IRON & STEEL CO.—This company announces that it has been compelled to put in a new 9 in. mill to take care of its increasing business. Its mills are located at Pittsburg, Pa.

MONTREAL LOCOMOTIVE WORKS.—The Secretary of State of Canada issued Supplementary Letters Patent on Feb. 5 changing the corporate name of "The Locomotive & Machine Company of Montreal, Limited," to that of "Montreal Locomotive Works, Limited."

RUMOR DENIED.—The Charles G. Smith Co., 603 Park Building, Pittsburg, Pa., announces that the rumor, which has been in circulation, to the effect that since its connection with the Pittsburg Emery Wheel Company it has discontinued the machine tool business, is not true.

ROUNDHOUSE BURNS.—The roundhouse and machine shops of the Central New England Railroad, at Fishkill Landing, N. Y., were destroyed by fire on February 13. In addition to the buildings there was a locomotive and a number of machine tools destroyed. The loss was about $100,000.

AMERICAN TOOL WORKS CO.—At the annual meeting of the stockholders and directors of the above company held on January 21, the following officers were elected: President, Franklin Alter; Vice-President and General Manager, J. P. Doane; Secretary, Robert S. Alter; Treasurer, Henry Luers.

MONARCH EMERY & CORUNDUM WHEEL CO.—Mr. Chas. A. Bacmeister has been appointed western representative of the above company, with headquarters at Chicago. Mr. Bacmeister has had an extensive experience in the grinding wheel field and his friends will no doubt be pleased to hear of his new connection.

FROST RAILWAY SUPPLY COMPANY.—At a meeting of the directors of the above company, held in Detroit on Tuesday, February 11, the following officers were elected: Mr. Harry W. Frost, president; Mr. George A. Cooper, vice-president; Mr. Frederick H. Holt, treasurer; Mr. James Whittemore, secretary, and Mr. H. C. Smith, assistant secretary.

THE DEARBORN DRUG & CHEMICAL WORKS.—Mr. Robert F. Carr and several of his associates in the above company, have purchased the holdings of the estate of the late Wm. H. Edgar and at a recent meeting of the stockholders the following officers were elected: Mr. R. F. Carr, president and general manager; George R. Carr and Grant W. Spear, vice-presidents; Wm. B. McVicker, vice-president and general manager; J. D. Purcell, assistant general manager; W. A. Converse, assistant secretary and chemical director; R. R. Browning, assistant treasurer and A. E. Carpenter, superintendent.

G. DROUVE CO.—At the annual meeting of the directors of the above company, held on Feb. 3, Mr. G. Drouve was elected president and treasurer, and Mr. William V. Dee secretary. Mr. Dee, who recently resigned from the staff of the *Railway Age*, has also been appointed general sales manager. This company manufactures the "anti-pluvius" sky-light, of which 125,000 sq. ft. have been installed at the Hoboken terminal of the D. L. & W. Railroad, and the Lovell window operating device, which is in use in the shops of many of the railroads, as well as the Drouve ventilators, drying stoves, etc. It will exhibit its sky-light and window operating device at the annual convention of the American Railway Engineering and Maintenance of Way Association, to be held at Chicago March 17 to 19.

PASSENGER CAR LIGHTING, CANADIAN PACIFIC RAILWAY.—The Safety Car Heating and Lighting Company has just completed the installation of 8,000 of its latest single mantel lamps in cars on the Canadian Pacific Railway. This type of mantel is capable of giving 99.5 candle power with a gas consumption of 2.12 cu. ft. per hour, which costs about one cent. These mantels have more than met the expectations of the company in regard to the length of service, as they have averaged a life of more than four months in actual srvice, while the expectation did not exceed a life of three months. In connection with this new equipment the Pintsch Compressing Company has completed the installation of plants at Vancouver, Moose Jaw and Winnipeg, Canada, and has arranged for charging facilities on the Canadian Pacific Railway at Montreal and Toronto.

CATALOGS

IN WRITING FOR THESE PLEASE MENTION THIS JOURNAL.

LOCK NUTS.—Wm. Howard Co., Philadelphia Bourse, is issuing a leaflet illustrating and describing the Blanton lock nut. This nut is made in sizes to fit bolts from ¼ to 4 in. in diameter.

tion are, in general, to be recommended, and in some cases duplicate machinery is desirable.

RECOMMENDATION OF 1908 COMMITTEE.

An abstract of the report on the "Best Types of Locomotive Coaling Stations for Various Conditions," as presented by the Committee on Buildings at the recent meeting of the American Railway Engineering and Maintenance of Way Association, is as follows:

"Your committee desires, however, at this time to emphasize the need of adequate fire protection at all coaling stations and to call attention to the possibilities of reinforced concrete construction of coaling stations and storage bins, which has been used in some instances, as a method of reducing fire risk, and at the same time securing structures of greater permanency than those ordinarily in use.

"The average insurance rates for open trestle timber construction coaling stations and reinforced concrete fireproof structures are, respectively, one per cent. and one-fourth of one per cent. This would mean that from the standpoint of fire insurance alone we would be justified in expending fifteen per cent. more for a reinforced concrete structure than for a timber coaling station. As the relative cost of the fireproof style of structure at present is about fifty per cent. above that of the heavy timber station, an expenditure of the extra twenty-five per cent. may, perhaps, be justified on the ground that the smaller chance of incidental losses due to interruption of traffic will warrant this additional expense.

"To the 'general information' in last year's report should be added that the 'Balanced Two-Bucket Type' of coal elevator is now built with auxiliary horizontal conveyors, which receive the coal from the elevator buckets and distribute it to bins and pockets, thus adapting it to use in larger coaling stations and storage plants than are practicable for the simple balanced bucket type of coaling station.

"In presenting the following conclusions your committee has been guided by the apparent practicability and adaptability of the various devices rather than by the available statistics regarding comparative costs of handling coal, which are, as has been stated, somewhat unreliable, and consequently not worthy to be accepted as the sole basis for comparison."

The following conclusions are an addition to those adopted at the meeting of 1907:

CONCLUSIONS OF 1908 COMMITTEE AS AMENDED.

(5) *"It is not possible to give absolute limits between which different types of coaling arrangements are to be used. Each installation must be considered as an individual problem. Prices of materials, cost and character of labor, the possible track arrangements, the amount of storage desired, the power and attendance, and shifting service available, all are to be considered.*

(6) *"Where the quantity of coal handled is small, particularly at terminal points where locomotives lie over night, it is recommended that the locomotives be coaled, either directly from cars or by handling from cars to a platform provided with a jib crane and one-ton buckets, and from these buckets to the locomotive.*

(7) *"At terminals, under certain conditions, a locomotive crane, with suitable bucket, is desirable, particularly where other work can be economically performed by the crane."*

(8) *"At terminals where the requirements do not exceed 300 tons a day, when the desired storage is not so great that auxiliary buckets are necessary and where a deep foundation is practicable, a 2-bucket hoist is recommended."*

(9) *"For terminals larger than those previously considered, the type of coaling station which should be selected as most desirable is dependent entirely upon local conditions. Where it is required that coal be delivered to not more than two tracks and where the necessary ground space is available, a coaling station of the 'trestle type,' with incline approach, is recommended. In yards where delivering locomotives are constantly available a plant with a five per cent. incline is preferable to one with a twenty per cent. grade operated by a hoisting engine. Where it is required to deliver coal to more than two tracks, or where the ground space for a 'trestle type' is not available, a 'mechanical conveyor type' is recommended."*

Weighing Coal Issued to Locomotives.

There are several methods by which the coal delivered to the locomotive tenders may be measured with more or less accuracy. Unfortunately most roads have several types of coaling stations, built from time to time, some of which measure or weigh the coal issued, while others do not.

Unquestionably the greatest gains which may be made in fuel economy are in its use on the locomotive. The enginemen, however, cannot be watched closely and spurred on to better efforts unless a careful check is kept on the coal consumption and on those things which effect it. This cannot be done unless some means is provided for measuring the coal issued to each engine with a fair degree of accuracy.

Under proper supervision there seems to be little question but what the average fireman could save one scoopful of coal in every ten. Would this not many times over warrant the installation of weighing or measuring devices on your road, also the establishing of a system of simple daily fuel performance reports, such as is described in another section of this article?

The simplest method of measuring the coal is the use of the jib crane and bucket system, or where "buggies" are used. The average weight of coal which one of these buckets or buggies will hold can easily be determined and care can be taken to see that they are loaded uniformly each time. As a large percentage of existing coaling stations are of the above types the practice on the Nashville, Chattanooga & St. Louis Railway, under the direction of Geo. M. Carpenter, fuel inspector, may be of interest.

Two standard sizes of buggies, holding two and three tons of run of mine coal each, are in use. It is the duty of the foremen at each chute to see that these are filled to capacity and a report is made to the fuel inspector each day as to the initial and number of the car from which each buggy is loaded and the number of the engine to which it is delivered. The fuel inspector can therefore check the weight of each car as against the mine weights, can easily find what kind of coal was used on any engine, and in case of poor coal can at once take the matter up with the inspector at the mine from which the coal was shipped.

The tanks on all the engines are graduated for each ton, the graduation being stenciled on the leg of the tank. This was done by weighing into a buggy one ton of coal, dropping it into the tender, leveling it off to a uniform depth and making a mark on the leg. This was repeated for each ton until the tank was filled level full. When an engine arrives at the roundhouse, at the end of a run, a man shovels the coal down from the sides and back of the tank, levels it up and marks on a coal ticket the "pounds on arrival." To this is added the amount of coal taken. It is thus possible to determine with a close degree of accuracy the amount of coal used on each trip, and with very little extra expense.

Another of the older types of coaling stations which allows the coal to be measured is the low trestle type with different size pockets into which the coal is shoveled from the cars. This type of station does not permit the use of self-clearing cars, and is becoming obsolete, but where it is in use the coal can be measured quite accurately if the pockets are properly calibrated.

With the large overhead storage pockets the problem becomes a more difficult one. The scheme has been tried of suspending the entire pocket and introducing a weighing dynamometer but it is of course necessary to have the pocket hang plumb in order to get accurate results; a wind or an eccentric loading interferes with this.

An arrangement which is being used successfully by several roads is to have an auxiliary pocket underneath the storage pocket. A simple scale arrangement is used for weighing this auxiliary pocket. Accurate results are attained and it is said to be inexpensive to maintain.

In the December, 1904, issue of this journal, page 65, coaling stations on the Baltimore & Ohio Railroad were illustrated and described which have auxiliary or delivery pockets under the

water in good condition, and insures better circuation in boiler. Result: Better steaming engine and a saving in coal.

DON'T allow the engine to slip. This is an unnecessary waste of coal, wears out tires and rails, causes great damage to pins, axles and running gear, and generally results in spoiling a fire.

DON'T pull out of a station with a train (after engine has stood for a while, and fire was allowed to get low) without first giving the fireman a chance to build up the fire. The time lost waiting to do this will save coal, and can better be made up before reaching the next station. Remember this when you get a time order.

DON'T leave the reverse lever down in corner longer than necessary when pulling out of stations. No rule can be made to govern how the throttle and reverse lever should be used. This must be acquired by practice and observing the performance of the engine. Bring the lever up gradually, as speed is acquired. The lever hooked well towards center of quadrant, with throttle well open, usually gives better results than using the throttle to govern the speed. Up to five years ago we considered it good practice with our smaller power to run with wide open throttle, and as short a point of cut-off as possible consistent with weight of train, but in our heavier and larger engines we find that it is better at many times to throttle the engine. Particular attention is called to all wide fire-box type locomotives. The engineer can permit the reverse lever in these engines to remain low in the quadrant when starting from a station, for a greater length of time than with the other types of locomotives, without pulling the fire or losing steam. When you are running on short time, it would be good judgment for the engineer to take advantage of this when pulling out from a station. In this engineers will use their best judgment.

DON'T put four or five or more shovelfuls of coal into the fire at once. One or two shovelfuls will give better results, and these two should not be thrown in the same spot. It is good practice to fire on one side of the box at one time, and the next time on the other side of the box, in order that the bright fire on one side may take up the gases from the fresh coal on the other side. This will reduce the smoke and give more steam.

Always fire as light as possible consistent with your work. Very heavy firing will make your flues and staybolts leak, and in time will crack your fire-box sheets. The reason for this is that when you have a very heavy fire, the air will not pass up through it readily, and the gases pass off, because there is not sufficient oxygen to unite with them to produce combustion, and as the gases must get air from somewhere, the air is then pulled through the fire-door, causing the chilling of flues and sheets as referred to above.

DON'T allow steam to escape at pops unnecessarily. Frequent blowing off at pops shows improper judgment, and implies that the engine crew is not practicing economy. Tests have demonstrated that ¼ lb. per second or 15 lbs. per minute is wasted. This amounts to about one ordinary scoopful, and in most cases may as well have been thrown on the ground as into the fire-box. There are only 188 scoopfuls in a ton of coal, so you can see that you would only have to have your pops open one hundred and thirty-three minutes in a whole day in order to throw a ton of coal away.

DON'T open the fire-box door to prevent steam blowing off at pops when engine is working: dropping dampers is a better practice. The supply of air is cut off, and combustion is partially suspended. When engine stops blowing off, open dampers again, before putting in coal. This method keeps fire in better condition and saves coal. You have no doubt noticed that on Class K Locomotives, when working hard on a hill, you have to shut your dampers in order to keep your fire from turning over. This is because the exhaust pulls too much air up through the grates, and causes your coal to be too active, and to prevent this activity of coal as well as increased combustion which follows, we consider it a good thing to drop your dampers, as per above.

DON'T insist on having the maximum steam pressure with pops opening occasionally when handling light trains, when less pressure will handle the train on time, thus avoiding the opening of pops.

DON'T forget, when engine is shut off for stations, to drop your dampers, opening the fire-box door slightly if necessary, and using the blower to carry off the black smoke.

DON'T blame the engine or coal, if engine is not steaming properly, before you have ascertained whether or not both of you are doing your duty. Talk it over; see if injector is not supplying more water than is being used, or that fireman is not firing too light or too heavy. Heavy firing is responsible for more poor steaming engines than the lighter method. You all know some engine crews have better success than others with the same engines and conditions. Think a little: there must be some cause for this.

DON'T wait until you get the signal to pull out before building up the fire. This should be done gradually until the proper thickness has been reached. A good fire to start with is essential to maintain the proper steam pressure, while engine is working hard getting train under way. Afterwards distribute the coal evenly on sides, ends and corners. Do this systematically, keeping in mind where you have placed the last shovelful, thus avoiding getting holes in fire,and prevent piling up coal all in one place. Endeavor to keep the steam pressure uniform, with as little black smoke as possible. Experience has taught that engines with draft appliances properly adjusted require very little coal in center of fire-box.

DON'T permit the water to get so high in boiler that it is carried over into the valves and cylinders. This usually occurs when pulling out of stations, and the water carries off the oil, which not only results in cut valves and cylinders, but the extra friction damages the entire valve motion, to the detriment of the power of engine and the coal record.

DON'T gauge the amount of water an engine will safely carry by water coming out of stack. Keep it low enough to insure dry steam being used, because moist steam has the same effect as water. Usually one-half glass or two gauges give best results. Be careful, however, that when ascending a grade, and you are about to pitch over the other side, that you have sufficient water to keep your crown-sheet thoroughly covered. If your custom has been to carry high water, try less and note results in better handling of tonnage, also saving in coal and oil.

DON'T neglect to take advantage of your excess steam before your engine is about to pop off, by making a heater of your injector, blowing steam back into the tank to warm the cold water, but avoid getting it so hot that the injector will not lift the water. By doing this you will keep your engine from blowing off at pops, when standing at stations after the boiler is filled up. You have all tried warming the water in the tank to help a poor steaming engine, with good results. What is good for a poor steaming engine will surely help a good steaming engine do better. Try it and you will find that it will not only save work for the fireman, but will make a better coal record for the engine crew, besides keeping the tank from sweating, which you are aware spoils paint.

DON'T think the fireman alone to blame for your coal record. The best and most economical fireman cannot make a showing with an engineer who supplies more water to boiler than is being used, and who shuts injector off only when boiler is pumped full. The proper handling of the injector is one of the most important matters in saving coal. Feed water to boiler according to demands. If on through train, keep water level as possible. If on way freight or switch trains, lose a little water between stations. Fill up again while drifting into, standing or switching at station. The advantages of supplying less water than is being used between stations are: It requires less coal to keep up steam pressure when running; also leaves a space so injector can be worked to avoid pops opening, and heavier fire can also be maintained to do switching, without the possibility of the fire being pulled.

DON'T pull out, after making a stop, with injectors working. The cool water introduced during period throttle was shut off is put in circulation throughout the boiler, and pointer on gauge drops back from five to twenty-five pounds. The fireman must then fire heavier to regain the lost steam, and naturally will use more coal. This condition exists also when engine has gone down grade with throttle shut or slightly open. Shut the injector off before opening the throttle. If this is not your practice, try it and note the difference.

DON'T wait for the pops to open, and use this as a signal to put on the injector. Keep an eye on the air gauge, steam gauge and water glass. You all know this can be done without detracting your attention from the track ahead. A look for an instant every mile or two will keep you informed, and is a good habit. Doing this will also keep you posted on air pressure, and may avoid difficulties should the air pump stop. The fireman should also keep an eye on the water glass, as the engineer is sometimes compelled to keep the injector at work to prevent the engine blowing off. When glass is full, the fireman should fire lighter, to give the engineer a chance to shut off the injector, and not have engine blow off. However, this condition should only exist when injector cannot be worked fine enough to just supply amount used. This sometimes occurs when card time is slow, or on down grade, or when running with light train.

DON'T put too much coal under the arch of engines with sloping fire-boxes, because these engines naturally pull the coal ahead, which results in forward section of grates becoming stuck and clinkered over, and fire is pulled in back end of fire box. Experience and observation will teach you to put most of the coal in back end of fire-box.

DON'T think engine having two fire-box doors requires twice the quantity of coal it would if it had but one. The extra door is for the purpose of distributing the coal more evenly over the grate surface, with less effort on the part of the fireman.

DON'T shovel large chunks of coal into fire-box, because you find them on the tank. The coal house men have instructions to break it the size of an apple. If not properly broken, report it to road foreman of engines or to master mechanic, instead of fellow engineers or firemen, but don't think it a hardship to break some occasionally. Better break it than to throw in large chunks. They are foundations for clinkers.

DON'T expect the fireman to fire the engine with one or two scoops to each fire, and also ring the bell for highway crossings and stations. Some engineers expect this. If engine is equipped with an air bell-ringer, get into the habit of starting the bell-ringer when blowing the whistle. By so doing, the habit will become as fixed as whistling for crossings and stations. Besides, it is just as important. Remember the engineer is responsible.

DON'T put in a heavy fire about the time the engine is shut off for a station or down-grade. The heavy cloud of black smoke is evidence the engine crew is not working in harmony or practicing economy. If on train that stops at all stations, the fireman should guard against it and learn when to stop firing. He will be governed by grade, service and weather conditions. If train does not make all station stops, the engineer should keep the fireman informed of intended stops.

DON'T forget that different qualities of coal and different makes of grate used, govern the shaking of grates. Coal that fills up and clinkers, requires more attention than the better grade. The object is to keep the grates free so the proper amount of air can be admitted.

DON'T neglect cleaning your fire on trains that are long hours on the road. Make use of the first opportunity. You will get better results with less labor and coal, and avoid leaky flues. Better clean out a small amount two or three times than not clean it at all.

DON'T take coal or water oftener than necessary, as it requires an extra amount of coal to again get a heavy train in motion, especially on a grade.

to stop for water or a meeting point could have beer used just as well.

Another waste is due to trains being made up improperly, loads behind instead of ahead, empty car doors open, short loads in what is supposed to be a through train, etc.

Slow orders put out by the maintenance department also add to the fuel bill, because unfortunately they are usually necessarily placed on track just at the foot of a grade or on a curve on some hard pull.

Many water tanks are located so that it is up-hill both ways away from them. Of course, the streams are usually found at the bottom of hills, but it is cheaper to pump water to a tank at the top of the hill than to pull the train from a standstill to the same point; stations are located so the train has to be stopped on a curve, and sidetracks so that with a full train the brakeman has to jump off and sprint for the switch, because "if they stopped they would have to double in."

LOCOMOTIVE FIRING.

The possibilities of fuel saving are probably greater after the coal has been placed upon the locomotive tender than at any other point in its journey from the mine to the ash pan. Considering a great majority of the locomotives in this country, which are easily within the capabilities of hand firing, and placing the limit at possibly two tons of coal per hour burned, we know that there is an enormous amount of waste, and in most cases needless waste, going on all of the time.

The qualifications of a good fireman are, first, intelligence or brightness and, secondly, physical strength and endurance. In a great majority of cases no large amount of strength is required for proper firing, in itself, and that factor enters into this problem, the same as it does in all similar lines of activity, only when the action is constant and continued for a long period of time. Even then we find that the best firemen are not usually those who can raise the heaviest weight, but rather the men of moderate strength and great endurance. They are the fellows who fire properly and keep everlastingly at it. Your strong man will handle more coal and work harder; will be exhausted and require a longer period of rest, all because he has performed much useless labor and incidentally has needlessly thrown away a large amount of valuable coal. Comparisons between the small wiry chap, who uses his head, and the big strong fellow, who heaves coal, are present at every division point in this country and almost universally result in the favor of the former, provided, of course, he has been given the proper instruction.

The results that can be obtained from the education of firemen have been most thoroughly discussed in the columns of this and other technical journals, as well as in papers before societies and clubs, but apparently have not been sufficiently impressive to cause the introduction of a practical course on most of our railways. A few of the companies are furnishing their men with literature going more or less fully into the theory of combustion and giving detailed instructions as to the proper method of firing, and still fewer have followed this up with a thorough course of individual instruction, but a very great majority have done neither and practically allow a new fireman to learn his business as best he can from his associates.

On divisions where the proper grade of men can be obtained and the work of instruction is systematically and conscientiously followed out, most gratifying results, in the shape of improved fuel records, increased interest in the work, and a contented and loyal set of firemen, are possible. Upon the other hand where either a low grade of men is all that is available, or where the work of instruction is done in a half-hearted or slip-shod way by incompetent instructors, the education of the firemen is bound to be a failure in all ways. There will always, of course, be individual cases that it will be impossible to do anything with. These will usually be found to be confined to the man with a strong back and a weak head (which some one has facetiously stated should be the qualifications of a fireman), who can get over the road because of his strength, but cases of good firemen quitting because they could not stand the work, which was easily within their strength if they had been properly instructed, are not by any means uncommon throughout the country, and it is this feature that causes the greatest regret that more attention is not being given to the subject of education. If you cannot get firemen of sufficient intelligence it is unfortunate, but if you don't keep those who are capable of learning, there is certainly a grave fault somewhere.

The lines that should be followed in educating the firemen are covered in a general way in a previous section of this article. As far as the actual placing of the coal on the fire is concerned they consist very largely in convincing the men, both by sound reasoning and actual example, that it will pay, and pay well, to scatter well broken coal in small amounts on various parts of the grate in succession, with such an interval between charges as will make it necessary to again cover the first point as soon as the whole grate area has been gone over. This, of course, with the ordinary locomotive, means continuous, but in most cases leisurely, work and gives no time for the seat box or anything else while the locomotive is working at full power. Opportunities for the needed rest will be given on the down grade stretches, the stops for water, the waits at meeting points or for orders and the shut-offs for signals, flags, etc. This is the way firemen should fire and the way an intelligent educated fireman will fire *provided* he is not expected to take care of ten or fifteen other things at the same time. He cannot and will not do it if he has to break all of his coal; if he has to climb up and shovel it down from the back of the tender every half hour or so; if he is expected to see every signal; if he has to clean out the ash pan at every stop for water; if he has to work against an injector that "forgets" or a couple of extra notches on the quadrant; if he is given dirt and slack for coal; if the competitive coal records are based on the guesses of an ignorant coal chute hand; if the records are posted six weeks after they are made; if an engine rated at 2,000 tons is habitually given 2,200 tons, etc., etc.

The education of firemen will pay if it is given a chance, but there is no use in teaching a man to do a thing properly and then arranging conditions so that it will be impossible for him to do it that way. Give a fireman a small shovel, not over 15 lbs. capacity, an automatic door opener and decent coal; teach him how to fire and if he is not loaded down with other duties and handicaps you will be surprised how little coal he will burn per ton mile or per car mile, as well as in the reduction of engine failures due to leaky flues and fire-boxes.

Of course there are many conditions affecting the efficiency of the firemen over which the motive power department has no control, and many others over which no one has control, all of which tend to neutralize the value of the properly educated fireman. But there are enough which can be controlled to make it very advisable to accompany a scheme of training firemen with a course of education and improvement along other lines. It is not an impossible condition to find master mechanics and even higher officials who are in need of a little educating in things which directly concern the firemen and the fuel bill.

There is one condition, however, which no amount of training or education will improve, and that is a locomotive of a size and power which no man can shovel coal enough into, properly or improperly, to develop its capacity. This would also include those locomotives which are capable of hand firing, only when everything is in perfect shape, and fall down under ordinary adverse conditions. At the present time there is no very large number of locomotives running in this country which would come strictly under this head and if we had only to consider these, there would be no great demand for mechanical stokers. There are, however, a large number of big engines which, from causes beyond the mechanical department's control, and seemingly incapable of correction, a few of which have been mentioned, are not able to give their full power with hand firing.

At some points it is impossible to get men for firemen who are of a sufficiently high order of intelligence to be able to learn to fire properly and economically. This may be due to a poor source of supply; to a rush of business compelling the acceptance of any one, or to working conditions and surroundings, which no self-respecting man will put up with. No matter what may be

STEEL PASSENGER EQUIPMENT.*

By Charles E. Barba and Marvin Singer.

THE UNDERFRAME.—PART III. (FORM I. CONTINUED.)

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THE CENTER SILLS AS A COLUMN.

Referring to the previous article.—In the last sub-heading the center sills were briefly dwelt upon in their capacity to act as a column to resist service shocks due to buffing. Therein was noted the fact that to solve the problem, considering the column as one with free ends and a length equal to the total length of the sills over the platforms, was foreign to the design and would introduce fictitious stresses running far above the ultimate strength of structural steel as given in the manufacturers' specifications. The conclusion, based upon this fact, was drawn that the design should be so worked out that short portions of the beams included between the transverse supports would partake of the nature of short compression pieces with fixed ends. The ends being fixed by the construction in the locality of such support would reduce the normal deflection, and hence the bending moment and stress at the center of each sub-span.

Rankine's formula:

$$S = \frac{P}{A}\left[1 + \theta\,\frac{l^2}{r^2}\right] \qquad \text{I}$$

was specified as being the best to apply to this case where

P = end shock (static).
A = sectional area.
l = span length in inches.
r = radius of gyration.
θ = constant depending upon the material and end construction, tables for which are given in Merriman's "Mechanics of Materials."

This formula shows that

$$S_1 = \frac{P}{A}$$

is a direct stress due to the buffing force being equally distributed over the area and that accompanying it is a stress

$$S_2 = \frac{P}{A}\,\theta\,\frac{l^2}{r^2}$$

due to the struts deflecting throughout the span and introducing flexural strains which reach the above value at the middle ordinate of the span. The proposition was advanced that this latter stress should be used as a measure of a uniform load which would produce a bending action of approximately the same amount throughout the beam. This uniform loading was noted to be considered as acting at right angles to the uniform loading imposed upon the same beams by the central floor and capacity loading. Quoting the final sentence: "This condition holds when the transverse supports are firm in a combination of either tension or compression and flexural stresses and the center sills have their greatest least radius of gyration about a vertical axis, as is true in this case."

To make this condition strictly true there should be added to the above necessities, that the connections at the platform ends should be such that any load, coming upon the buffers or end casting, would be taken concentrically by the center sill beams. This is a feature which must not be overlooked under penalty of having destructive secondary stresses brought into action by the bending moment due to the eccentric action of the end shock about the vertical neutral axis of these beams.

The preliminary study for necessary sections may be hasty and many refinements may be avoided, but a final investigation should be made of each design using net areas and whatever expedients are necessary to secure a just appreciation of what the frame will measure up to when put to the test.

Though this article pays most attention to the idea that the center sills as struts will deflect in a horizontal transverse plane, there is a possibility that the car may so alter the conditions that it will be the vertical longitudinal plane instead. The final investigation then should cover the latter assumption and the fitness of the calculated beams should be examined as if the end shock was acting about the horizontal neutral axis of these sills and as a consequence with a tendency to augment the bending due to the vertical lading. This is a natural consequence of concentric end loads acting upon a side loaded girder—that they tend to increase the present deflection. The conditions surrounding this type of underframe design are peculiar, in that the sills are so much weaker in the horizontal plane than the vertical that when the supports are spaced close enough to fulfil the short strut conditions demanded of the center sills they will still be found to be weaker in this plane even after the effect of the lading in the vertical plane has been imposed. There are certain constructive features, such as weights of lading, size of beams and disposition of transverse supports, which introduce disturbing elements and no hard and fast rule can be laid down concerning the line of weakness. Both planes must accordingly be solved.

Eccentric End Loads.—The fact that the end load hardly ever impinges concentric with the vertical, due to the end design, will not be dealt with at any length here, as this same question of eccentric loading has been discussed in a previous section (January, 1908, p. 13). In that case the load was eccentric in the horizontal plane, but the principle remains the same, except that in this case the forces and leverages are at quadrature to what they were in that one. This principle involves the addition of the eccentricity of load application to the maximum deflection of each span for total leverage of the end load to secure the maximum bending moment. In this case the general equation of the arm would be the same

$$e + \int_{x=\bullet}^{x=\frac{l}{2}} Y\,dx$$

where e represents this eccentricity in inches and Y represents the equation of the elastic curve. This equation must here be made

* Copyright, 1908, by Chas. E. Barba.

BURNING LIGNITE COAL IN LOCOMOTIVES

By O. N. Terry.*

In certain sections of this country the sub-bituminous and lignite coals are practically the only fuels available. The coal mined in the vicinity of Sheridan, Wyoming, is a sub-bituminous coal, but is commonly called lignite,† and where the word lignite is used in this article it should be understood to mean Wyoming or Northern Colorado coal, which in many respects is superior to the average bituminous coal. It is light and clean and almost entirely free from slate or rock. It ignites quickly and burns freely with practically no clinkering, when properly handled. It differs from the bituminous principally in the amount of moisture and ash, the moisture being usually higher than with bituminous coal and the ash lower. When exposed to the sun and air it soon begins to slack and break up into small cubes, which eventually crumble into powder. It is therefore advisable to put it on the locomotive tender without any unnecessary delay after it is mined.

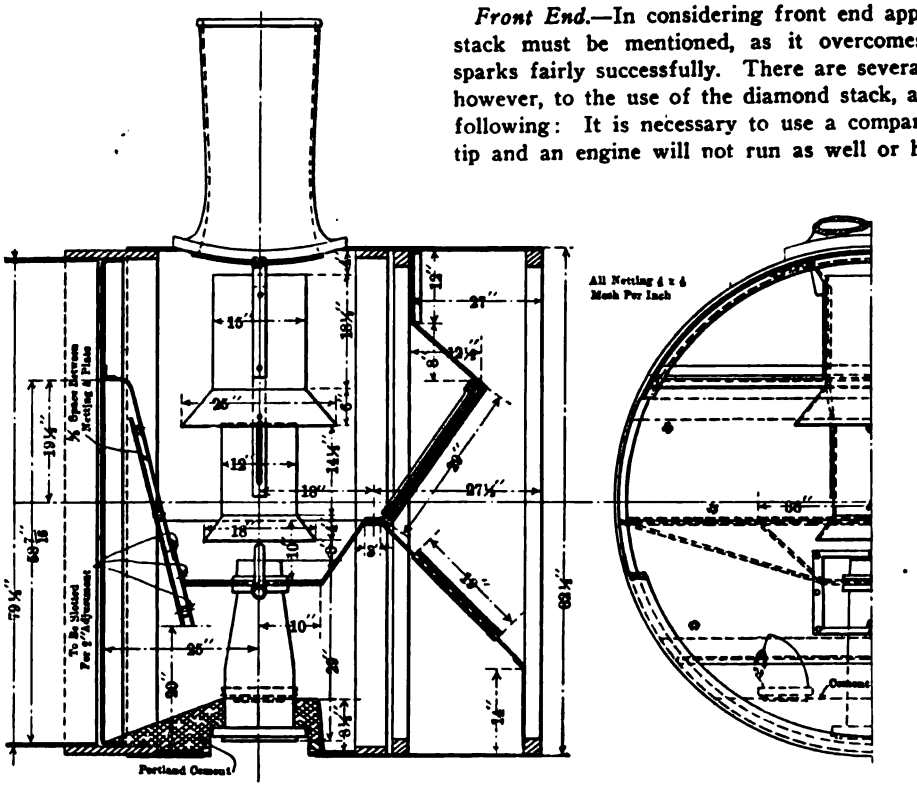


FIG. 2.—FIRST FORM OF FRONT END WITH STRAIGHT STACK USED FOR BURNING LIGNITE ON THE BURLINGTON.

Lignite does not coke when burning, but breaks up into small pieces which are kept moving by the draft when an engine is working hard. As these particles burn, and decrease in size, they eventually reach a point where the draft is strong enough to carry them up, over the arch, through the flues and out of the stack. It is a peculiar property of lignite that these small pieces generally burn until they are entirely consumed, and it is necessary that they be reduced to a very small size before they are permitted to escape. It is therefore apparent that the importance of adequate spark arresting appliances is greater than with bituminous coal. The ash pan should be as tight as possible without any direct openings below the level of the mud ring, that are not covered by small mesh netting. Sufficient air opening may be secured by extending the sides of the ash pan out beyond and slightly above the lower edge of the mud ring, or by leaving space between the ash pan and the mud ring, which is covered with netting.

Grates.—The grate shown in Fig. 1 has proved to be very satisfactory for lignite. It was originally designed with the idea that the increased air opening would reduce the amount of fire lifted from the grates. It is impossible to determine if it has had such an effect, but other advantages, such as simplicity, cheapness, durability, fewer connections, reduction of engine failures, etc., have made it a success.

Brick Arch.—It is generally the practice in burning lignite coal to use a large arch so that the sparks and gases will be consumed before going into the tubes. This should be fitted tightly against the flue sheet and there should be no holes in the arch between the various bricks.

Front End.—In considering front end appliances the diamond stack must be mentioned, as it overcomes the trouble from sparks fairly successfully. There are several serious objections, however, to the use of the diamond stack, among which are the following: It is necessary to use a comparatively small nozzle tip and an engine will not run as well or handle as much tonnage as it otherwise would. The diamond stack is disagreeable to the enginemen on account of fine cinders coming down around and inside the cab. It is expensive to maintain as the cone, netting and top part of the stack cut away rapidly. This of course makes it correspondingly difficult to keep the stack in safe, serviceable condition.

The first form of front end arrangement used with a straight stack on the Burlington road for burning lignite is that shown in Fig. 2. In this arrangement 4 x 4 mesh, No. 12, wire netting was used, coming forward from the diaphragm on the level of the nozzle tip. About half way between the nozzle tip and the front end one layer of netting ran down to a point about even with the lower part of the door opening, and another netting extended up in a zig-zag form to the top of the smoke box. A layer of netting, with an open basket or flare, extended up around the nozzle tip. When both of the front end nettings were clean the majority of the sparks would strike the lower front netting and pass up through the second netting. Generally, however, after running a short distance the upper front netting would stop up with cinders and cinders would accumulate under the lower front netting, frequently causing it to burn out. Upon

* Chief Draftsman, Burlington Lines West of Missouri River.

† Lignite from the Wyoming Coal Mining Company's mines, at Monarch, Wyoming (Sheridan Co.), on the Burlington & Missouri River Railroad, was tested at the coal testing plant of the United States Geological Survey, at the Louisiana Purchase Exposition, St. Louis. The proximate analysis of this coal was as follows:

Moisture	21.97 per cent.
Volatile matter	35.95 " "
Fixed carbon	37.75 " "
Ash	4.32 " "

The calorific value is about 9,700 B. T. U.

POWER REQUIREMENTS OF RAILROAD SHOP TOOLS.*

BY L. R. POMEROY.

Generally speaking, the generator capacity for railroad repair shops is equal to approximately 15 kw. per locomotive pit, or space in erecting shops occupied by one locomotive. This includes the requirements for tools, cranes, heating, blower and exhaust fans: *i.e.*, provides for all power required except that needed for lighting.

The tools alone require about 9 or 10 kw. per pit; the heating, and the blower and exhaust fans demand 5 kw. per pit, while 3 kw. per pit will care for the ordinary shop and adjacent yard lighting. If in addition to shop requirements, power is needed for lighting terminal yards, buildings, etc., an increase in generator capacity must be made to cover such demands.

The accompanying curves and tables are submitted to cover the horse power requirements of the machine tools generally found in railroad repair shops.

The extensive tests made by Dr. Nicholson of the Manchester Technical School, England, confirm the correctness of the foregoing formula, and form a very interesting contribution to the subject. A careful analysis of the results of these experiments shows the average horse power required at the motor, per pound of metal removed per minute, to be as follows:

Medium or soft steel or wrought iron	2.4 h.p.
Hard steel	2.65 h.p.
Cast iron, soft or medium	1.00 h.p.
Cast iron, hard	1.36 h.p.

Using the symbols of previous formula the horse power becomes:—

$$F \times D \times \text{f.p.m.} \times 12 \times N \times W \times K \qquad (2)\dagger$$

where W equals the weight in pounds of a cubic inch of the metal, and K is the coefficient for that metal as given above. The value of W for the different metals is as follows:—

Cast iron	.0.258
Wrought iron	0.278
Steel	0.284

The following examples illustrate the more or less heavy cuts to which reference has been made; the larger powers given are exceptional, while the average requirements are far below these,

BOLT AND NUT MACHINERY, HELVE HAMMERS, MULTIPLE DRILLS, ETC.

	Motor h.p. required to drive
1½" single head bolt cutter	1½
Pratt & Whitney No. 4 turret bolt cutter	2
2 spindle stay bolt cutter	2
1½" Acme double head bolt cutter	2½
1½-2½ Acme nut facer	2½
6 spindle nut tapper	3
1½" triple head bolt cutter	3
¾-2½" double head bolt cutter	3
2" triple head bolt cutter	5
4 spindle stay bolt cutter	5
Bradley hammer	7½
Niles 4 spindle multiple drill	7½

PUNCHES AND SHEARS.

	Motor h.p. required to drive
No. 4, 36" throat, L. & A. punch	3
No. 9 horizontal flange punch	5
No. 2 Hillis & Jones combination punch and shear	5
Alligator shear (stock 5" x 1")	5
Lenox rotary bevel shear	7½
36" multiple tank plate punch with spacing table	7½
No. 3 Hillis & Jones combination punch and shear, 12" throat	7½
No. 2 horizontal punch 20" throat	7½
No. 3 Hillis & Jones combination punch and shear, 36" throat	10
No. 3 angle shear 5" x 1" bar	10

SAWS.

	Motor h.p. required to drive
Band saw, 36" wheel	3
Band saw, 42" wheel	5
Swing cut off saw	5
Band saw, 48" wheel	7½
Greenlee 1½ self-feed rip saw	10
Greenlee vertical automatic cut off saw	15
40"-46" saws	15
Auto. band resaw	20
Greenlee No. 6 aut. cut off saw	20
Greenlee No. 3 rip saw	20
Woods No. 4 rip saw	20
Extra heavy aut. rip saw	25

GRINDERS.

	Motor h.p. required to drive
Air cock grinder	1
No. 3 Brown & Sharp universal grinder	3
Link grinder	3
Sellers universal grinder for tools	5
Norton 18" x 96" piston rod grinder	5

MILLERS.

	Motor h.p. required to drive
Vertical miller, Becker-Brainard No. 2	1
Valve miller No. 2	2
Universal miller No. 3, Brown & Sharp	2
Universal miller No. 4, Brown & Sharp	3
Universal No. 6, Becker-Brainard	5
Niles heavy vertical	10

WOOD WORKING TOOLS.

	Motor h.p. required to drive
Fay-Egan single spindle vertical boring machine	3
Fay-Egan 3 spindle vertical boring machine	4
Fay-Egan No. 6 vertical mortiser and borer	6
Fay-Egan No. 7 tenoner or gainer	7½
" universal wood worker	7½
" 4 spindle vertical borer	7½
" 5 spindle vertical borer	10
14" inside moulder	12
Fay-Egan universal tenoner and gainer	12
" vertical tenoner	12
Greenlee aut. vertical tenoner	15
Fay-Egan No. 3 gainer, also Greenlee	15½
Greenlee Ex. Range 5 spindle borer and mortiser	15
Greenlee vertical mortiser	15
Fay-Egan auto. gainer, also comb. gainer and mortiser	20
Fay-Egan No. 5 vertical saw and gainer	20½
Vertical hollow chisel mortiser and borer	20
Fay-Egan 14½" double cyl. surfacer	20½
Heavy outside moulder	20
6 roll D. C. planer and matcher	25
Double cylinder fast flooring machine	30
Double cylinder planer and matcher	30
Fay-Egan No. 8 auto. tenoner	30½
Woods No. 27 matcher	35
4 side timber planer, heavy	60

Occasionally certain tools are selected for the purpose of performing extra heavy service, to utilize the full capacity of the new rapid cutting tool steel, as is now done in manufacturing shops. In such cases the power to drive the machine must be figured on the basis of service required, but as these cases are few and exceptional, the curves will be found to meet the majority of conditions, and the exceptions can be taken care of by the following formula:

$$\text{Horse power to drive} = F \times D \times \text{f.p.m.} \times 12 \times N \times C \qquad (1)$$

Where:—

F = feed in inches
D = depth of cut in inches
f.p.m. = feet per minute
N = number of tools cutting
C = a constant with the following values, depending on the class of material:—

Cast iron	0.35 to 0.5
Soft steel or wrought iron	0.45 to 0.7
Locomotive driving wheel tires	0.70 to 1.00
Very hard steel, such as crucible steel driving wheel tires	1.00 to 1.10

This formula is based on Prof. Flather's dynamometer tests, which check up fairly well with actual motor tests, and it is therefore submitted with confidence.

As an example of its accuracy, the aggregate horse power of 45 tests made with various tools was 247.7, while the calculated aggregate horse power by formula equalled 247.2.

and all are submitted as actual cases which have come under the writer's observation:

(a) 100 inch driving wheel lathe—(material steel driving wheel tires) 5/16" feed, 5/16" cut, at 18.5 feet per minute—two tools cutting. Substituting in formula (1) we have:—
$5/16 \times 5/16 \times 18.5 \times 12 \times 2 \times C = 40$ h.p.
Same lathe, 3/16" feed, ¼" cut, at 16 f.p.m.—two tools cutting
$3/16 \times ¼ \times 16 \times 12 \times 2 \times C = 16$ h.p.

(b) Old 76 inch driving wheel lathe, (material driving wheel tires)
$1/16 \times 1/4 \times 16 \times 12 \times 2 \times C = 5$ h.p.

(c) Steel tired wheel lathe (material engine truck wheels)
$1/7 \times 5/16 \times 16 \times 12 \times 2 \times C = 17$ h.p.

(d) Planer (material cast iron)
5/32" × 3/8" × 16' × 12 × 0.35 (one tool cutting).....4.5 h.p.
(two tools cutting).....9 h. p.

(e) Planer (material wrought iron engine frame)
5/32" × 1/2" × 16' × 12 × 2 × 0.5 (two tools cutting)...15 h.p.

(f) 76 inch boring mill (on cast steel driving wheel centers)
1/8" × 3/4" × 30' × 12 × 3 × 0.45 (three tools cutting)..45 h.p.
Same machine boring driving wheel tire
1/8" × 3/16" × 28' × 12 × 2 × 1 (two tools cutting)....15 h.p.

(g) 84 inch boring mill (on 62" cast iron wheel centers)
1/8" × 1/10" × 30' × 12 × 3 × 0.35 (three tools cutting) 4.7 h.p.
Same mill boring 44" steel tire
1/4" × 3/32" × 96' × 12 × 2 × 1 (two tools cutting)...14.5 h.p.

(h) The following is a special test on an extra heavy driving wheel lathe, and gives results representing unusual conditions. The operator was given a heavy bonus to develop the ultimate capacity of the machine.
Average feed 0.4625", depth 0.0423", at 12.2 f.p.m. (two tools cutting).

These figures are the averages of 37 tests, and represent a consumption of 46 h.p., while the maximum h.p. required was about 65. The machine was equipped with a 40 h.p. direct current motor with 2.1 speed variation.

* From the October, 1907, issue of the *General Electric Review*.

† W × K in formula (2) = C in formula (1). For cast iron W × K = .258 × 1.00, or 1.36 = .258, or .35. For wrought iron W × K = .278 × 2.4 = .667. For hard steel W × K = .284 × 2.65 = .75.

$$\text{Capacity per year} = \frac{(\text{Number of pits}) \times 300}{\text{Average number of days in shop.}}$$

In order to reduce to about 20 the average number of days in the shop that are required for general overhauling, it is estimated that the machine shop adjacent to the erecting shop should contain seven machine tools per engine pit, and the floor area in order to accommodate seven tools per engine capacity should be about 1500 square feet per pit.

Power required for air compressors equals the delivery of free air in cubic feet per minute, at 100 lbs. pressure of the compressor, multiplied by 0.14.

Modern erecting and machine shops, including heating, cranes, etc., cost from $2.50 to $3.50 per square foot of inside measurement

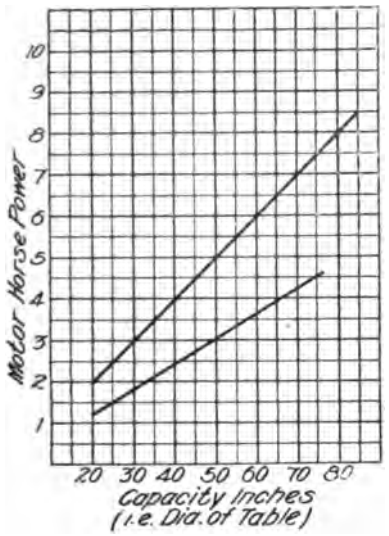
$$\text{Rate per kw. hour to cover fixed charges} = \frac{\text{total fixed charges per year}}{(\text{max. demand}) \times 8760 \times (\text{load factor})}$$

Illustration:

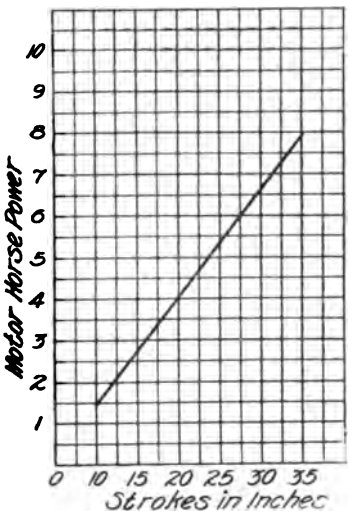
Fixed charges	$8330.00
Maximum demand	500 kw.
Load factor	83 per cent.

Then:

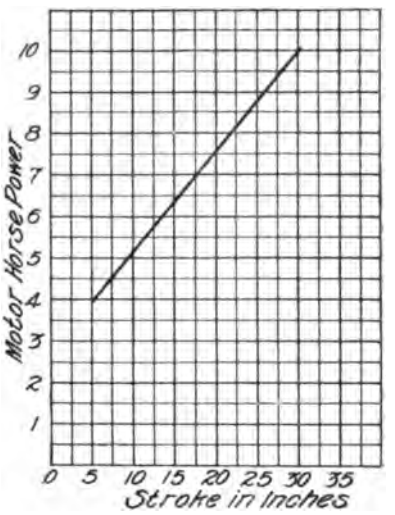
$$\text{rate} = \frac{\$8330}{500 \times 8760 \times .83} = 0.0057$$



DRILL PRESS, 15 TO 20 FT. PER MIN.



SHAPER, 15 TO 20 FT. PER MIN.



SLOTTER, 15 TO 20 FT. PER MIN.

RESULTS OF THE ELECTRIFICATION OF THE NEW YORK CENTRAL & HUDSON RIVER RAILROAD.*

WILLIAM J. WILGUS.

Initial Zone Operation.—As previously stated, the company was forced to confine temporarily the change of motive power to the operation of the suburban zone terminating at High Bridge, 7 miles out; and at Wakefield, 13 miles from the terminal. This postpones for two or three years the extension of electrical service to the northerly termini of the suburban zone. In the meantime, the power on through trains is changed at the temporary termini. At the same points, multiple-unit trains north-bound have steam locomotives attached and thence proceed as non-electric trains; and south-bound the steam locomotives are detached and the trains continue by electricity without locomotives. The average time required for making the changes, including that lost in slowing down and regaining speed is as follows:

Through trains with locomotives	4½ min.
Multiple-unit trains, north-bound	3 "
Multiple-unit trains, south-bound	2½ "

On the Hudson Division this delay has been largely compensated by shortening the line at Marble Hill and the elimination of the grade track crossing at Spuyten Duyvil.

RESULTS.

Expectations from Electrification.—Now that the change of motive power in the initial electric zone has been completed for sufficient time to gain at least a preliminary idea of the results, the question naturally arises, with what success has the change met expectations?

It has already been explained that the principal reasons for undertaking the work were twofold:

(1).—Demand of the public for the abolition of the nuisances incident to the use of steam locomotives south of the Harlem River; and

(2).—Need for increased capacity of the terminal, by the elimination of a large proportion of the switching movements required with steam locomotive practice; and relief to the main line entrance to the terminal by reducing its use for haulage of dead locomotives and cars to Mott Haven.

As secondary considerations there were:

(3).—The possibility of sufficient economy in operation at least to offset largely the additional fixed charges on the cost of the electrical installation; and

(4).—Opportunities for an ultimate large increase in traffic and corresponding growth of revenue to justify the expenditure for all improvements within the suburban zone.

What do the observations made thus far disclose?

The first two expectations have been completely realized.

Park Avenue Tunnel.—The atmospheric conditions in the Park Avenue Tunnel show marked improvement, even with the presence of the remaining New Haven Company's steam service.

Increased Terminal Capacity.—The effect on the operating efficiency of the terminal has been very gratifying, the increased capacity being estimated at one-third. There has also been a large reduction in the number of shop or "dead" trains to and from Mott Haven.

Reduced Cost of Operation.—The results, as regards the third expectation, have been most surprising. The operation, for a considerable period, of steam and electric equipment side by side has afforded an unexampled opportunity for a true comparison of costs of operation. Until now, data on this subject have been based on theory, ignoring many of the indeterminate features of actual operation that have such a weighty effect on costs. For instance, among the variables entering into an analysis of this character are:

(a).—Cost and quantity of coal and water at the power station, and on the steam locomotive tender;

(b).—Relation of ton-mileage of the motive power to total ton-mileage, including motive power and cars;

(c).—Frequency and volume of traffic;

* From a paper on "The Electrification of the Suburban Zone of the New York Central & Hudson River Railroad in the Vicinity of New York City," presented at the March 18, 1908, meeting of the American Society of Civil Engineers, see page 69, Number 2, Volume XXXIV, of the *Proceedings*. The paper is very extensive and complete. It considers the reasons for the electrification of the New York Central; also the reasons for the adaption of direct-current and other important features. It discusses at length the general features of construction and equipment and closes with the section on "Results."

The application of individual motors to the older tools was described in connection with a series of articles which were published in this journal during the years 1903 and 1904. A description of the locomotive repair shops at McKees Rocks was also published during these years.

BOILER EFFICIENCY

In his paper on the heat balances in locomotives, presented before the Institution of Mechanical Engineers of Great Britain, parts of which are given in this issue, Mr. Lawford H. Fry states that some recent tests on the Pennsylvania Railroad locomotive testing plant at Altoona show that the boiler efficiency is independent of the grate area and that it makes no difference whether the same total amount of coal per hour is burned on 55.5 sq. ft. of grate area, at 72 lbs. per sq. ft. per hour, or on 29.76 sq. ft. at 134 lbs. per sq. ft. per hour. These experiments were all made on the same locomotive and it is explained that the reason lies in the fact that the firebox volume, which was constant, is the controlling factor.

From this it would appear that in the case of a locomotive with large grate area, which did not properly cut its fire, the bushing of the nozzle might be avoided by simply bricking over a section of the grate, thus giving more draft through the fire without decreasing the efficiency of the boiler or the locomotive.

Mr. Fry also arrives at some other interesting conclusions from his study of the St. Louis and Altoona tests, one of which is that the efficiency of the absorption of the heat by a boiler is practically independent of the rates of combustion and evaporation and that under all conditions of working the heating surface will absorb about 80 per cent. of the heat produced by the combustion. This figure seems to be more or less independent of the design of the boiler and of the ratio of the heating surface to grate area. From this it will be seen that the efficiency of the boiler as a whole is mainly determined by the efficiency of the combustion, which in the same firebox falls rapidly as the total amount of coal burned per hour is increased.

BURNING LIGNITE COAL IN LOCOMOTIVES.

There are large deposits of lignite in the northeastern part of Wyoming; the southeastern part of Montana; the western portion of North Dakota, and the northwestern part of South Dakota. As may be seen from the analysis on the first page of this issue, this coal is very low in ash, although the amount of moisture is higher than that in the ordinary bituminous coal. It is free from slate and rock and burns easily, with no clinkering. It can be mined cheaply, but disintegrates quickly when exposed to the air, so that it must be used as soon as possible after being removed from the mine. The railroads in this northwestern district have made several attempts to burn this coal, because of the great expense of hauling bituminous coal from Iowa, Illinois, Missouri and the coal producing states in that district. If the lignite can be burned successfully it will not only greatly reduce the cost of locomotive fuel in this district, but will tend to develop the coal mining industry along the lines which pass through this territory.

While the lignite is used more or less for industrial purposes the fact that it disintegrates so quickly interferes with the mines operating and storing up coal during the time of year when the industrial requirements are low; if the railroads could use the coal it would keep the mines operating efficiently the year round. While all of the roads passing through the district have studied the matter of its use closely and have experimented with it more or less, only one road is using it extensively at the present time. The objection to its use in locomotives is in the fact that it is very light and the sparks which are carried out through the stack set fire to the surrounding country. The small particles of burning lignite which pass out hold the fire for a long time until they are entirely consumed. The climate in this district is particularly dry, so much so that it has been said that the trainmen must be very careful as to the language they use while passing through it in the dry season in order not to set it on fire. The Burlington Railroad has been experimenting with this fuel for a number of years and has finally perfected the grate and front end arrangements of its lignite burning engines, so that when the engines are evenly and properly fired, practically no sparks escape. However, under the average condition of firing, even with the best arrangements which have been worked out, some few sparks do escape. It would appear that this difficulty can be entirely relieved by the introduction of a successful spark arrester.

A number of the roads in the middle west are making a careful study of this question at present and it is quite probable that its final and complete solution is near at hand. The progress which has been made on the Burlington, which at present is burning about 3,000 tons of this fuel per day, is carefully traced in an article, by Mr. O. N. Terry, on "Lignite Burning in Locomotives" on page 161 of this issue.

NEW YORK SUBWAY CARS.

At the present time the New York subway car equipment consists of 500 composite cars, in which some wood is used, 300 all metal, strictly fireproof cars and 50 all metal cars, which have been recently delivered. The first 800 cars are practically the same size, with the same seat and door arrangement. The last 50 have wider doors and have only one bank of cross seats in the center of the car. There are 10 longitudinal seats on each side, instead of nine, making the seating capacity of the last 50 cars 48 instead of 52, as on the first cars.

The operation of these cars in subway service has disclosed certain fundamental defects in design which should be remedied before the subway can furnish the speed, comfort and capacity which the passenger has a right to expect. Mr. Bion J. Arnold recently submitted an extensive and very complete report upon the subway car to the Public Service Commission for the First District of the State of New York. His conclusions are that the present car when provided with an additional side door, located near each end, thus making four doors in each side of the car, will best meet the conditions of the present subway and that when these cars are properly operated through the stations as rapidly as the signal system, when modified as recommended in a previous report, will permit, a marked increase in the capacity and comfort of the subway will be realized. The following is a brief abstract of Mr. Arnold's report:

At each express station the passenger has the privilege of transferring from the local trains to the express trains, and vice versa, and to facilitate this transferring the five express stations are arranged with island platforms between the tracks, so that the passengers can leave the trains of one service, cross the platform, and directly enter the cars of the other service. This privilege is much used, and even abused to a great extent; owing to the excessive use of this transfer privilege many passengers, in traveling from their starting points to their destinations, are loaded and unloaded twice, and a large number of them three times, so that many of the passengers use the car doors four times, and some six times. On account of the excessive use of the doors the present type of car, which ordinarily gives satisfactory service, has proved to be entirely inadequate for the subway.

At the present time it is possible, except on very busy days, to get 30 trains an hour through the limiting stations on both the local and the express tracks. During rush hours the cars often carry twice as many passengers as there are seats and during the height of the rush periods there are times when three times as many passengers are carried on some express cars as there are seats, although the latter condition exists for only short periods of time on very busy days. Since the extension of the subway to Brooklyn the time table has called for 40 express trains per hour between 96th street and Brooklyn Bridge during the rush periods. The delays of the trains at the station platforms, however, have seriously interfered with the carrying out of this schedule, and although there are parts of the system where 40 trains per hour are supplied during certain periods of the day, this rate is not maintained at the critical part of the

SELLERS MOTOR DRIVEN CAR WHEEL BORING MILL.

MOTOR DRIVEN CAR WHEEL BORING MILL.

A recent type of Sellers 54-inch motor driven car wheel boring mill, with improved automatic chuck, friction feed discs and crane attachment, is shown in the illustration. The machine is of heavy, substantial construction, capable of taking the heaviest cuts required for this class of work.

The chuck closes, centers and opens automatically. It has three adjustable abutments, as shown, each provided with an equalizing steel jaw, with two bearing points. The work is thus accurately centered by six points on the circumference. The first movement of the driving shaft causes the jaws to close in upon the wheel, after which the motion is transmitted to the table to produce rotation. When the work is completed the chuck is released by disengaging the driving clutch and retarding the driving shaft by means of a friction brake. The inertia of the table and work imparts the necessary force to automatically open the jaws without loss of time. As the power of the clutch grip increases with the resistance of the cut it is never necessary to stop the machine to tighten the chuck.

A Westinghouse type S, 7½ h.p., motor is mounted on the frame of the machine, provision being made for a vertical movement of the motor on its base for tightening the belt. The motor has a variation in speed of approximately 2 to 1. The motor furnishes a number of speed steps within this range, so that the machine thus equipped can be operated more efficiently than the belt drive with cone pulleys.

A HUNDRED MILLION TIES A YEAR.

In the construction of new track and for renewals, the steam and street railroads used, in 1906, over one hundred million cross-ties. The average price paid was 48 cents per tie. Approximately three-fourths of the ties were hewed and one-fourth sawed.

Oak, the chief wood used for ties, furnishes more than 44 per cent., while the southern pines, which rank second, contribute about one-sixth. Douglas fir and cedar, the next two, with approximately equal quantities, supply less than one-fifteenth apiece. Chestnut, cypress, western pine, tamarack, hemlock, and redwood are all of importance, but no one of them furnishes more than a small proportion.

Oak and southern pine stand highest in both total and average value; the average value of each is 51 cents. Chestnut ranks next, followed by cedar. Hemlock, at 28 cents, is the cheapest tie reported.

More than three-fourths of all ties are hewed. In general, when lumber has a relatively low value the proportion of sawed ties increases, because the market for ties is always active, while that for lumber is frequently sluggish. All western species are affected by this condition, for stumpage is abundant and its value relatively low.

Ten per cent. of the ties purchased were treated with preservatives either before they were purchased or at the treating plant of the railroad company. At least ten railroad companies are operating their own plants for the preservation of their construction material.

It has been calculated that the amount of wood used each year in ties is equivalent to the product of 600,000 acres of forest, and that to maintain every tie in the track two trees must be growing.

With nearly 300,000 miles of railroad trackage and approximately 2,800 ties to the mile, there are over 800,000,000 ties constantly subject to wear and decay. The railroads report that in the forms of ties cedar lasts eleven years, cypress ten years, and redwood nine years. These woods, however, lack the desired weight and hardness, and, what is more important, they are not available in the region of the trunk lines of the Central and Eastern States. When it is considered, then, that the service of the longest-lived tie timbers in general use—chestnut, white oak, tamarack, spruce, and Douglas fir—is but seven years, while with some, as the black oaks, it is but four years, whereas a treated tie with equipment to lessen wear will last fifteen years, it is apparent how much the railroads can save if preservative treatment of ties is universally adopted. The saving in the drain upon the forests is of even greater moment.

Details of the consumption of ties in 1906 are contained in Circular 124, just issued by the Forest Service in co-operation with the Bureau of the Census. This pamphlet can be secured by application to the Forester at Washington, D. C.

HIGH SPEED STEEL.

In a discussion regarding the manufacture and up-keep of milling cutters, at a meeting of the Institution of Mechanical Engineers, of Great Britain, one of the speakers called attention to a valuable property of high-speed steel, which he had not seen referred to, namely, that of withstanding shocks. In one of the railway shops in England, the output of the crank-turning lathes had been practically doubled by the use of high-speed steel tools. The forgings were never very accurate, there being perhaps ¼ inch to take off one side of the diameter, and 1½ inch off the other, and a tool suited to such wide variation was greatly appreciated. If the high-speed steel tool dug in, it did not break, as invariably happened with ordinary carbon steel.

Another speaker called attention to an important factor affecting the life of high-speed steel milling cutters. The teeth, besides being correctly relieved at the back, should have a front rake of 5 degrees. The number of teeth in milling cutters, par-

A TABULAR COMPARISON OF NOTABLE EXAMPLES OF RECENT LOCOMOTIVES

ARRANGED WITH RESPECT TO CLASSES AND WEIGHTS

PASSENGER LOCOMOTIVES OF TYPES OTHER THAN THE PACIFIC AND PRAIRIE

TYPE.	ATLANTIC. (4-4-2.)										TEN WHEEL. (4-6-0.)					AMERICAN. 4-4-0)		
Name of road	U. P.	Erie	C. M. & St. P.	P. R. R.	N. Y. N. H. & H.	C. B. & Q.	Har. Lines	C. R. I. & P.	G. W. (Eng.)	P. R. R.	B. & A.	S. P.	D. L. & W.	N. Y. C.	C. & N. W.	C. R. R. of N. J.	D. L. & W.	L. S. & M. S.
Road number or class	21	537	951	2,760	F1	P3	A-81	1,019	40	2,512	1,916	2,317	1,012	2,099		852	955	Pony
Builder	Baldwin	Amer.	Bald.	Amer.	Amer.	Bald.	Bald.	Amer.	Gt. West.	Soc. Als.	Amer.	Bald.	Amer.	Amer.	Amer.	Amer.	Amer.	L.S & M.S.
When built	1906	1905	1907	1905	1907	1904	1905	1905	1906	1904	1908	1907	1905	1905	1907	1905	1905	1906
Simple or compound	Comp.	Comp.	Comp.	Comp.	Simple	Comp.	Simple	Simple	Simple	Comp.	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple
Tractive effort, lbs	24,281	23,860	22,200	23,300	24,670	21,400	23,560	24,700	25,036	19,530	31,000	36,570	35,100	31,000	30,900	23,120	23,710	15,700
Weight, total, lbs	209,000	206,000	204,119	200,500	200,000	196,600	196,000	191,300	166,880	164,000	208,000	203,300	201,000	194,500	179,500	161,300	151,200	126,600
Weight on drivers, lbs	110,000	115,000	105,966	117,200	105,500	101,200	105,000	107,100	88,704	87,850	158,000	160,000	154,000	148,000	135,500	111,300	100,000	85,100
Weight on trucks, lbs	53,000	52,000	52,353	52,500	48,000	54,200	45,000	42,400	40,096	41,250			47,000	46,500	44,000	50,000	51,200	41,500
Weight on trailer, lbs	46,000	39,000	45,800	30,000	46,500	41,200	46,000	40,800	38,080	34,900	155,800	43,300						
Weight, tender loaded, lbs	162,200	162,800	130,000	132,500	134,000	120,400	162,200	144,000	89,600	132,500		141,366	120,000	143,500	139,500	122,200	110,000	105,200
Wheel base, driving	7′ 0″	7′ 0″	7′ 6″	7′ 5″	7′ 3″	7′ 3″	7′ 0″	7′ 0″	7′ 0″	7′ 1½″	15′ 10″	13′ 10″	14′ 4″	15′ 10″	14′ 10″	8′ 3″	8′ 6″	9′ 0″
Wheel base, engine	27′ 10″	24′ 0″	32′ 2″	31′ 11″	28′ 2″	30′ 2″	27′ 7″	27′ 5½″	27′ 9″	28′ 6⅛″	26′ 10½″	25′ 10″	25′ 6″	26′ 10½″	25′ 10″	23′ 1½″	24′ 5″	25′ 1½″
Wheel base, engine and tender	58′ 5″	60′ 9″	66′ 9″	61′ 4″	56′ 1″	57′ 6¼″	58′ 2″	57′ 2″	53′ 6¼″	59′ 5″	59′ 3″	58′ ⅛″	54′ ¾″	59′ 2″	57′ 9″	49′ 2″	51′ ⅜″	48′ 4¾″
Diameter of drivers	81″	78″	85″	80″	79″	78″	81″	73″	80½″	80 ⅛″	69″	63″	69″	69″	63″	69″	69″	63″
Cylinders, number	4	4	4	4	2	4	2	2	4	4	2	2	2	2	2	2	2	4
Cylinders, diameter	16″ & 27″	15½ & 26″	15″ & 25″	16″ & 27″	21″	15″ & 25″	20″	21″	14¼″	14.5 & 23½″	22″	22″	21½″	22″	21″	19″	20″	12½″
Cylinders, stroke	28″	26″	28″	26″	26″	26″	28″	26″	26″	25⅛″	26″	28″	26″	26″	26″	26″	26″	20″
Valve gear, type	Wals.	Steph.		Steph.		Steph.	Steph.	Steph.	Steph.	Wals.			Steph.	Steph.	Wals.	Steph.	Steph.	Wals.
Steam pressure, lbs	200	220	220	205	200	210	200	185	225	227½	200	200	215	200	200	200	185	180
Boiler, type	Str.	E. W. T.	W. T.	Belp.	E. W. T.	E. W. T.	Str.	Str.	Belp.	Belp.	E. W. T.	W. T.	Str.	W. T.	E. W. T.	W. T.	Str.	W. T.
Boiler, smallest diameter	70″	70¾″	66″	65⅛″	68″	64″	70″	72″	58¾″	59½″	72¼″	72″	74½″	70⅝″	66⅜″	62¼″	61⅛″	50″
Boiler, height center	113″	111⅜″	114″	109″	110″	108⅛″	113″	108″	98″	106⅛″	115″	102″	116½″	115″		113″		78″
Heating surface, tubes, sq. ft.	2475.	3453.6	3008.	2680.2	3041.	3050.5	2475.	2227.6	1988.65	2435.7	3104.5	2788.	3156.3	3124.7	2808.4	1838.1	1947.9	1,326.
Heating surface, firebox, sq. ft.	180.	181.1	168.	181.4	204.4	155.5	174.	161.8	154.26	181.1	203.3	206.	221.7	202.7	150.8	167.6	190.8	140.
Heating surface, total, sq. ft.	2655.	3634.7	3194.	2861.6	3245.4	3206.	2649.	2389.4	2142.91	2616.8	3307.8	2994.	3378.	3326.7	2959.2	2005.7	2138.7	1,466.
Heating surface, superheater, sq. ft.								338.										
Grate area, sq. ft	49.5	56.5	45.	55.5	53 5	44.1	49.5	44.8	27.07	33.9	54.9	32.1	94.8	54.93	46.27	81.6	87.54	21.
Firebox, length	108″	108⅛″	107″	111″	108⅛″	96⅛″	108″	96″	98⅛″	119¾″	105⅛″	124″	126⅛″	108⅛″	102⅛″	122⅛″	126⅜″	96″
Firebox, width	66″	75¾″	60⅛″	72″	71¾″	66¾″	66″	67¾″	38½″	40	75⅛″	37¼″	108¾″	75¾″	65¼″	96¾″	100″	31″
Fuel, kind	Bit. coal	Bit. coal.	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Oil	Anth. coal	Bit. coal	Bit. coal	Anth. coal	Anth. coal	Bit. coal
Tubes, number firetube	297	388	268	315	347	264	297	173	250	139*	400	355	398	400	337	280	280	187
Tubes, number superheater								54										
Tubes, diameter, firetube	2″	2″	2¼″	2″	2″	2¼″	2″	2″	2″	2⅛″	2″	2″	2″	2″	2″	2″	2″	2″
Tubes, diameter, superheater								3½″										
Tubes, length	16′ 0″	17′ 0″	19′	16′ 3″	16′ 10″	19′ 0″	16′ 0″	16′ 0″	15′ 2⅛″	14′ 5½″	14′ 11″	15″	15′ 3″	14′ 11″	16′ 0″	12′ 6″	13′ 4¼″	13′ 6½″
Tender, coal capacity, tons	10	16	10	12½	14	12	10	12		12½	12	2,940	10	12	10	12	10	10
Tender, water capacity, gals	9,000	8,500	7,000	5,500	6,000	6,000	9,000	7,000	3,500	5,500	8,000	7,000	6,000	7,000	7,500	5,000	5,000	4,300
Weight on drivers ÷ tractive effort	4.53	4.82	4.75	5.	4.27	4.7	4.48	4.2	3.7	3.5	5 10	4.37	4.38	4.77	4.38	4.8	4.22	5.4
Weight total ÷ tractive effort	8.6	8.63	9.20	8.6	8.10	9.2	8.35	7.8	6.64	8.4	6.70	5.57	5.72	6.27	5.80	6.95	6.4	8.1
T. E. × diam. drivers ÷ total H. S.	740.	513.	610.	650.	600.	518.8	717.	754.	943.	600.	647.	770.	717.	647.	655.	800.	765.	670.
Total heat. surf. ÷ grate area	53.8	64.3	70.50	51.6	60.50	73.	53.6	53.3	78.8	77.5	60.20	93.	35.6	60.5	64.	24.7	24.4	69.5
Firebox heat. surf. ÷ total H. S. %	6.8	5.	5.30	9.37	6.30	4.85	6.6	6.75	7.2	6.9	6.15	6.90	6.6	6.1	5.10	8.4	8.9	9.5
Wgt. on drivers ÷ total heat. surf.	41.5	31.7	33.10	41.	32.60	31.5	39.6	44.8	41.4	33.6	51.	53.40	45.6	44.5	45.75	55.3	46.8	58.
Wgt. total ÷ total heat. surf.	78.9	56.8	64.	70.	61.80	61.3	74.	80.	78.	62.6	67.	68.	59.8	58.7	60.50	80.5	71.	86.5
Total H. S. ÷ superheating heat. surf.								7.08										
Cylinder volume, cu. ft.	10.2†	8.93†	9.†	10.2†	10.40	8.3†	10.2	10.4	9.6	7.15†	11.40	12.30	10.9	11.4	10.4	8.6	9.5	5.7
Total heat. surf. ÷ cyl. vol.	262.	408.	355.	280.	311.	387.	260.7	230.	223.	367.	288.	243.	311.	292.	287.	233.	224.	257.
Sup. heat. surf. ÷ cyl. vol.								32.5	69.									
Grate area ÷ cyl. vol.	4.83	6.27	5.	5.42	5.16	5.3	4.85	4.3	2.82	4.72	4.8	2.61	8.68	4.8	4.45	9.5	9.2	3.68
Reference in THE AMERICAN ENGINEER	1906 p. 308	1905 p. 287	1908 p. 37	1906 p. 73	1907 p. 471	1904 p. 212	1905 p. 154	1905 p. 329	1907 p. 57	1904 p. 203		1907 p. 481	1905 p. 407	1906 p. 59	1907 p. 247			1906 p. 293

* Serve tubes. † Equivalent simple cylinders.

A TABULAR COMPARISON OF NOTABLE EXAMPLES OF RECENT LOCOMOTIVES

ARRANGED WITH RESPECT TO CLASSES AND WEIGHTS

PASSENGER LOCOMOTIVES OF THE PACIFIC (4-6-2) AND PRAIRIE (2-6-2) TYPES

TYPE	PACIFIC													PRAIRIE				
Name of road	P. R. R.	N. Y. C.	N. P.	A. T. & S. F.	Erie	R. F. & P.	B. & O.	N. Y., N.H. & H.	C. B. & Q.	Mex. Nat.	A.T. & S.F.	Har. lines	A.T. & S.F.	L.S. & M.S.	C. B. & Q.	N. P.	G. N.	Wabash†
Road number or class	K 28	3565	2,175	1290	2,511	84	P	I 1	S1	420	1,251	p.141	1800	4,724	R5	2,378	J1	G1
Builder	Amer.	Amer.	Amer.	Bald.	Amer.	Bald.	Amer.	Both	.....	Bald.	Bald.	Bald.	Bald.	Amer.	Amer.	Amer.	Bald.	Both
When built	1907	1908	1906	1908	1905	1907	1906	1907	1906	1907	1905	1905	1906	1906	1906	1906	1906	1907
Simple or compound	Simple	Simple	Comp.	Simple	Simple	Simple	Simple	Simple	Simple	Comp.	Comp.	Simple	Comp.	Simple	Simple	Simple	Simple	Simple
Tractive effort, lbs	30,700	29,200	30,340	32,600	30,300	31,100	35,020	31,560	31,100	35,066	32,800	29,920	37,800	27,850	35,060	33,300	37,560	34,558
Weight, total, lbs	272,500	266,000	240,000	232,750	230,500	230,800	229,000	229,500	228,090	227,340	226,700	222,000	248,200	233,000	216,000	209,500	209,000	205,900
Weight on drivers, lbs	183,900	171,500	157,000	140,400	149,000	143,750	150,500	142,500	150,000	147,040	151,900	141,000	174,700	165,200	152,000	152,000	151,000	150,500
Weight on trucks, lbs	.....	.....	53,000	54,950	41,000	46,850	40,500	46,500	42,000	.....	35,800	37,000	31,300	26,000	25,600	.....	21,000	21,900
Weight on trailer, lbs	.....	.....	30,000	37,400	40,500	40,200	38,500	41,000	36,000	.....	39,000	44,000	42,200	41,800	38,400	.....	37,000	.....
Weight, tender loaded, lbs	143,800	164,000	141,350	165,200	163,000	350,000	147,000	134,000	148,200	142,660	.....	162,200	175,000	159,900	148,200	139,500	151,000	153,000
Wheel base, driving	13′ 10″	14′	12′ 0″	12′ 8″	13′ 0″	12′ 10″	13′ 2″	13′ 1″	12′ 10″	12′ 0″	13′ 8″	13′ 4″	13′ 8″	14′ 0″	13′ 4½″	11′ 0″	13′ 0″	13′ 4½″
Wheel base, engine	35′ 2½″	36′ 6″	33′ 5″	34′ 4¾″	33′ 8″	32′ 8″	34′ 3½″	33′ 5½″	32′ 9″	33′ 11″	34′ 0″	33′ 4″	33′ 9″	34′ 3″	30′ 8½″	28′ 11″	30′ 9″	30′ 8½″
Wheel base, engine and tender	67′ 3½″	67′ 11″	62′ 10″	65′ 2″	65′ 1″	61′ 11½″	66′ 3¾″	61′ 2″	64′ 3½″	62′ 11″	66′ 1½″	63′ 10½″	65′ 0″	62′ 5¼″	62′ 2¾″	57′ 3½″	63′ 8″	61′ 4¾″
Diameter of drivers	80″	79″	69″	73″	74″	73″	74″	73″	74″	67″	73″	77″	69″	79″	69″	63″	69″	70″
Cylinders, number	2	2	4	2	2	2	2	2	2	4	4	2	4	2	2	2	2	2
Cylinders, diameter	24″	22″	16½″ & 27½″	25″	22½″	22″	22″	22″	22″	17″ & 28″	17″ & 28″	22″	17½″ & 29″	21½″	22″	21″	22″	22″
Cylinders, stroke	26″	28″	26″	28″	26″	28″	28″	28″	28″	28″	28″	28″	28″	28″	28″	28″	30″	28″
Valve gear, type	Wals.	Wals.	Wals.	.....	Steph.	.....	Steph.	.....	Steph.	Steph.	Steph.	Steph.	Wals.	Wals.	Steph.	Steph.	Wals.	Steph.
Steam pressure, lbs	205	200	220	160	200	200	225	200	200	220	220	200	225	200	210	200	210	210
Boiler, type	Str.	Conical	E. W. T.	Str.	Str.	Str.	Str.	Str.	W. T.	W. T.	W. T.	Str.	E. W. T.	E. W. T.	W. T.	E. W. T.	Belp.	E. W. T.
Boiler, smallest diameter	78″	72″	72¾″	72″	74⅝″	74″	72″	70″	70″	70″	70″	70″	76″	70″	70″	72⅛″	72″	70″
Boiler, height center	119″	.....	115″	114¼″	113½″	112½″	112″	110″	109¾″	109″	.....	113″	115″	114″	107½″	115″	108″	107⅛″
Heating surface, tubes, sq. ft	4243	3981.6	2667.	3202	3131.	3917.	3,234.6	3743.	3,732.	3,527.	3,402.2	2,874.	3,803.	3,678.	3,375.	2,105.	3,277.	3370
Heating surface, firebox, sq. ft	205	228.3	241.8	190	195.	190.	179.4	204.4	200.	186.	192.8	174.	217.	227.	200.	235.	210.	190
Heating surface, total, sq. ft	4448	4209.9	2908.8	3392	3326.	4107.	3,414.	3947.4	3,932.	3,713.	3,595.	3,048.	4020.	3,905.	3,575.	2,340.	3,487.	3560
Heating surface, superheater, sq. ft	.....	.....	.....	.....	763.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Grate area, sq. ft	61.86	56.5	43.5	49.5	56.5	49′ 5″	56.24	53.5	54.	52.1	53.	49.5	53.8	55.	54.	43.5	53.15	54.25
Firebox, length	111″	108⅛″	96″	107⅜″	108⅛″	108″	108⅛″	108⅛″	108⅛″	113⅝″	108″	108″	107⅛″	108⅛″	108⅛″	96″	116″	108⅛″
Firebox, width	80⅛″	75¼″	65¼″	66″	75½″	66″	75¼″	71¼″	72¼″	66¼″	71¼″	66″	71¼″	73¼″	72¼″	65¼″	66″	72½″
Fuel, kind	Bit. Coal	Bit. Coal	Bit. Coal.	Oil	Bit. Coal	Bit. Coal	Bit. coal	Bit. Coal	Bit. coal.	Bit. coal	Oil	Bit. coal	Bit. Coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal
Tubes, number firetube	343	382	306	273	195	318	276	310	303	301	290	245	342	322	303	306	301	303
Tubes, number superheater	.....	.....	.....	.....	32	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Tubes, diameter, firetube	2¼″	2″	2″	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″	2″	2¼″	2¼″
Tubes, diameter superheater	.....	.....	.....	.....	5″	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Tubes, length	21′	20′	16′ 9″	20′	20′ 0″	21′	20′ 0″	20′ 6″	21′ 0″	20′ 0″	20′ 0″	20′ 0″	18′ 10⅛″	19′ 6″	19′ 0″	13′ 3″	18′ 6″	19′
Tender, coal capacity, tons	11	14	12	33,009	16	12	15	14	13	12	3,300	12	14	15	13	12	13	15
Tender, water capacity, gals	7000	8000	7,000	8,500	8,500	6,000	7,000	6,000	8,000	7,500	8,500	9,000	9,000	8,000	8,000	7,000	8,000	7,700
Weight on drivers ÷ tractive effort	6.00	5.84	5.2	4.33	4.95	4.62	4 3	4.5	4.8	4.2	4.6	4.7	4.6	4.4	4.3	4.6	4.	4.35
Weight, total ÷ tractive effort	8.85	9.11	7.9	7.12	7.7	7.65	6.6	7.25	7.3	6.5	6.9	7.4	6.6	8.3	6.2	6.3	5.6	5.95
T. E. × diameter drivers ÷ total H S	550.00	550.00	720.	700.00	669.	560.00	760.	565.00	585.	632.	666.	755.	650.00	565.	677.	900.	746.	680.00
Total heating surface ÷ grate area	72.00	74.50	67.	68.50	58.7	82.90	60.5	73.50	71.3	71.2	68.	61.5	74.	71.	64.8	53.8	65.	65.70
Firebox heat. surf. ÷ total H.S. %	4.62	5.35	8.3	5.60	5.85	4.64	5.23	5.20	4.85	5.	5.35	5.70	5.4	5.8	5.34	10.1	6.0	5.32
Weight on drivers ÷ total heat. surf	41.50	40.70	53.8	41.50	45.	34.90	44.	36.20	38.	37.4	42.	46.5	43.5	42.	42.5	65.	43.5	42.20
Weight total ÷ total heating surface	61.20	63.10	82.5	68.50	69.5	56.10	66.5	58.20	58.	61.1	63.	73.	62.	61.	60.7	89.5	60.	58.00
Total H.S. ÷ superheating heat. surf	.....	.....	.....	.....	4.35	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Cylinder volume, cubic feet	13.60	12.32	9.9*	16.00	12.	12.30	12.3	12.30	12.3	11.6*	11.6*	12.3	12.1*	11.7	12.3	11.2	13.2	12.32
Total heating surface ÷ cyl volume	326.00	341.00	294.	212.00	277.	334.00	278.	321.00	318.	330.	3.10	248.	334.	335.	290.	209.	265.	290.00
Superheating heating surf. ÷ cyl vol	.....	.....	.....	.....	63.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Grate area ÷ cylinder volume	4.55	4.58	4 3	3.10	4.7	4.03	4.56	4.20	4.39	4.54	4.55	4.	4.43	4.68	4.46	3.89	4.03	4.41
Reference in THE AMERICAN ENGINEER	1907 p. 267	1908 p. 164	1906 p. 411	1908 p. 112	1905 p. 172	1907 p 407	1906 p. 257	1907 p. 431	1906 p. 300	1907 p. 70	1905 p 454	1905 p. 154	1906 p. 435	1906 p. 204	1906 p. 300	1906 p. 392	1906 p.365	1908 p. 31

* Equal equivalent simple cylinders. † Designed for fast freight service.

A TABULAR COMPARISON OF NOTABLE EXAMPLES OF RECENT LOCOMOTIVES

ARRANGED WITH RESPECT TO CLASSES AND WEIGHTS

FREIGHT LOCOMOTIVES OF OTHER TYPES THAN THE CONSOLIDATION

TYPE	MALLET				SANTA FE 2-10-2		DECAPOD 2-10-0	MIKADO 2-8-2		12-WH'L 4-8-0	10-WHEEL 4-6-0			0-10-0	0-8-0	0-6-0		
Name of road	Erie	G. N.	B. & O.	G. N.*	P. S. & N.*	A. T. & S. F.	B. R. & P.*	N. P.	N. P.	N. & W.	T. & P.	C. & E. I.	C. P. R.	L. S. & M. S.	C & O.	P. & L. E.	P. R. R.	B. & O.
Road number or class	2,600	L-1	2,400		98	900		W.	1,608	N1	375	289	D-10	M.	8	253	B-6	D-23
Builder	Amer.	Bald.	Amer.	Bald.	Bald.	Bald.	Amer.	Amer.	Amer.	Both	Amer.	Bald.	C. P. R.	Amer.	Amer.	Amer.	P. R. R.	Amer.
When built	1907	1906	1904	1907	1907	1903	1907	1905	1906	1907	1907-8	1905	1905-6	1905	1903	1906	1904	1906
Simple or compound	Comp.	Comp.	Comp.	Comp.	Simple	Tan. comp.	Simple	Tan. comp.	Simple	Simple	Simple	Bal. comp.	Simple	Simple	Simple	Simple	Simple	Simple
Tractive effort, lbs	94,800	71,600	70,000	57,760	60,000	62,800	55,350	45,000	46,630	40,163	38,400	31,000	33,300	55,300	41,000	44,100	36,100	29,740
Weight, total, lbs	410,000	355,000	334,500	288 000	288,000	287,240	275,000	271,000	261,000	200,000	197,000	191,060	190,000	270,000	171,175	178,200	170,000	161,080
Weight on drivers, lbs	410,000	316,000	334,500	250,000	235,000	234,580	248,000	207,000	205,000	168,000	165.000	145,260	141,000	270,000	171,175	178,200	170,000	161,080
Weight on trucks, lbs		19,000		18,000		23,420		30 300	26,000	32,000	32,000	45,800	49,000					
Weight on trailer, lbs		20,000		20,000		29,240		33,700	30,000									
Weight, tender loaded, lbs	167,700	148,000	143,000	152,000	162,000	158,500	162,000	148,500	177,800	116,600	132,867	120,000	123,700		121,160	121,300	132,500	85,000
Wheel base, driving	14′ 3″	10′ 0″		9′ 10″	19′ 9″	19′ 9″	19′ 0″	16′ 6″	16′ 6″	15′ 6″	14′ 10″	13′ 6″	14′ 10″	19′ 0″	13′ 7½″	12′ 0″	11′ 6″	11′ 0″
Wheel base, engine	39′ 2″	44′ 10″	30′ 8″	43′ 7″	35′ 11″	35′ 11″	28′ 4″	34′ 9″	34′ 9″	26′ 5″	26′ 4″	27′ 7″	26′ 1″	19′ 0″	13′ 7½″	12′ 0″	11′ 6″	11′ 0″
Wheel base, engine and tender	70′ 5½″	73′ 2½″	64′ 7″	72′ 0¼″	67′ 4½″	66′ 0″	65′ 3½″	63′ 1″	63′ 1″	53′ 7″	55′ 9½″	55′ 8″	54′ 6¾″	54′ 5½″	45′ 8″	46′ 2½″	49′ 3½″	40′ 9½″
Diameter of drivers	51″	55″	56″	55″	57″	57″	52″	63″	63″	56″	63″	62″	63″	52″	51″	50″	56″	52″
Cylinders, number	4	4	4	4	2	4	2	4	2	2	2	4	2	2	2	2	2	2
Cylinders, diameter	25″ & 39″	21½ & 33″	20″ & 32″	20″ & 31″	28″	19″ & 32″	24″	19″ & 30″	24″	21″	22″	15½″ & 26″	21″	24″	21″	21″	22″	19″
Cylinders, stroke	28″	32″	32″	30″	32″	32″	28″	30″	30″	30″	28″	26	28″	28″	28″	30″	24″	28″
Valve gear, type	Wals.	Wals.	Wals.	Wals.	Wals.	Steph.	Wals.	Steph.	Wals.	Wals.	Wals. ‡	Steph.	Steph.	Wals.	Steph.	Steph.	Steph.	Steph.
Steam pressure, lbs	215	200	235	210	160	225	210	200	200	200	210	225	200	210	200	200	205	180
Boiler, type	Str.	Belp.	Str.	Belp.	E. W. T.	W. T.	Conical.	E. W. T.	E. W. T.	W. T.	E. W. T.	W. T.	E. W. T.	W. T.	W. T.	Str.	Belp.	Wooten
Boiler, smallest diameter	84″	84″	84″	72″	78¾″	78¾″	80″	75½″	75½″	70″	70⅛″	64″	70⅜″	80⅛″	67″	80″	67⅛″	70″
Boiler, height center	120″	120″	120″	116″	118″	118″	116″	118″	118″	112″	114⅜″	109″	113⅛″	115″	112½″	108½″	108″	105″
Heating surface, tubes, sq. ft	4,971.5	5,473	5,380	3,708	4,586	4,587	3,280	3,819	3,192	2,605	2,731	2,933.7	2,233	4,422.6	2,573	2,906	2,343.	1,476.67
Heating surface, firebox, sq. ft	343.2	230	220	198	210	209	255.5	209	245 †	173	200	160.7	180	197.	164	206	152.1	172.84
Heating surface, total, sq. ft	5,313.7	5,703	5,600	3,906	4,796	4,796	3,535.5	4,028	3,437	2,778	2,931	3,094.4	2,413	4.619.6	2.737	3,112	2,495.1	1,649.5
Heating surface, superheater, sq. ft					762								378					
Grate area, sq. ft	100	78	72.2	53.4	58.5	58.5	55.5	43.5	43.5	45	46.3	46.69	49.5	55.4	38.8	33.3	41.25	73.3
Firebox, length	126⅛″	117″	108¼″	116¼″	108″	108″	108″	96″	96″	99½″	99″	101⅞″	102¼″	108⅛″	80″	120″	90″	110″
Firebox, width	114¼″	96″	96¼″	66¼″	78″	78″	73¾″	65¼″	65¼″	64⅝″	67¼″	66″	69⅞″	73¼″	70″	40″	66″	96″
Fuel, kind	Bit coal.	Bit. Coal.	Bit. Coal	Bit. Coal	Bit. Coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Anth. co
Tubes, number firetube	404	441	436	301	391	391	404	374	372	242	326	278	266	447	351	430	3.25	220
Tubes, number superheater													22					
Tubes, dimeter, firetube	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″	2″	2″	2″	2¼″	2″	2¼″	2″	2″	2″	2″	2″	2¼″
Tubes, diameter, superheater													5″					
Tubes, length	21′	21′ 0″	20′ 10⅜″	21′ 0″	20′ 0″	20′ 0″	15′ 6″	19′ 6″	16′6″	18′ 4⅞″	16″	18′ 0″	14′ 2⅞″	19′ 0″	14′ 0″	13′ 0″	13′ 10¼″	11′ 6″
Tender, coal capacity, tons	16	13	16	13	14	14	14	12	12	10	12	12	10	12	7	10	11	6
Tender, water capacity, gals	8,500	8,000	7,000	8,000	8,500	8.500	9,000	8,000	10,000	6,000	6.500	6,000	5,000	8,000	6,000	7,000	5,500	4,000
Weight on drivers ÷ tractive effort	4.32	4.4	4.75	4.34	3.91	3.75	4.47	4.6	4.38	4.20	4.30	4.67	4.24	4.86	4.15	4.04	4.7	5.4
Weight, total ÷ tractive effort	4.32	4.95	4.75	5.00	4.8	4.56	5.12	6.0	5.6	4.98	5.13	6.15	5.7	4.86	4.15	4.04	4.7	5.4
T. E. × diam. drivers ÷ total H. S.	910.00	690.	700.	813.	712.	747.	812.	705.	855.	810.00	825.00	620.	870.	625.	763.	710.	810.	940.
Total heating surface ÷ grate area	53.14	73.	77.3	73.	81.8	81.8	63.3	92.5	78.8	61.60	63.50	66.	48.6	83.	70.5	94.	60.3	22.5
Firebox heat. surf. ÷ total H. S., %	6.46	4.13	3.92	5.05	4.38	4.34	7.2	5.18	7.12	6.25	6.80	5.18	7.42	4.25	5 98	6.6	6.08	10.5
Weight on drivers ÷ total heat. surf	76.90	55.2	59.5	63.9	49.	48.8	70.1	51.1	59.6	60.50	56.00	46.7	58.5	58.3	62.3	57.1	68.	97.3
Weight total ÷ total heating surface	76.90	62.	59.5	73.8	60.	59.8	80.3	66.9	75.5	72.00	67.00	61.6	78.5	58.3	62.3	57.1	68.	97.3
Total H.S. ÷ superheating heat. surf					6.3								6.39					
Cylinder volume, cubic feet	24.00	20.75	19.	17.1	22.82	17.9	14.6	15.8	15.8	12.00	12.30	8.93	11.2	14.7	11.2	12.	10.5	9.2
Total heating surface ÷ cylinder vol	222.00	275.	295.	229.	210.	268.	243.	255.	218.	231.00	236.00	346.	215.	314.	245.	260.	238.	179.
Superheating heating surf. ÷ cyl. vol					33.4								33.8					
Grate area ÷ cylinder volume	4.70	3.75	3.85	3.14	2.57	3.28	3.81	2.75	2.76	3.75	3.78	5.2	4.43	3.78	3.48	2.77	3.95	7.95
Reference in THE AMERICAN ENGINEER	1907 p. 341	1906 p. 371	1904 p. 237, 262	1907 p. 213	1907 p. 88	'03 p. 372, 398 1904 p. 176	1907 p. 133	1905 p. 367	1906 p. 392	1907 p. 444	1908 p. 77	1905 p. 97	1906 p. 165	1905 p. 330	1904 p. 184	1906 p. 346	1904 p. 384	1906 p. 257

* Builders' weights. † Combustion chamber 3′ long. ‡ 20 Walschaert and 20 Stephenson valve gear.

A TABULAR COMPARISON OF NOTABLE EXAMPLES OF RECENT LOCOMOTIVES

ARRANGED IN ORDER OF TOTAL WEIGHTS

FREIGHT LOCOMOTIVES OF THE CONSOLIDATION OR 2-8-0 TYPE

Name of road	N. Y. S & W.	D. & H.	L. S. & M. S.	L. S. & M. S.	P. R. R.	Wabash	A. T. & S. F.	B. & O.	Har. lines	C. S. N. O. & P.	P. R. R.	C. N. O. & T. P.	C. B. & Q.	M. St. P. & S. S. M.	W. P.	C. R. I. & P.	C. P. R.	C of G.
Road number or class	140	1,011	5,962	G-46	2,762	.....	1,950	2,503	C-187	.....	H 6 B	734	D4	445	.....	55D	M4	1,200
Builder	Bald.	Amer.	Amer.	Amer.	Amer.	Bald.	Bald.	Amer.	Bald.	Bald.	Bald.	Both	Amer.	Amer.	Bald.	Bald.	Shops	Bald.
When built	1906	1906	1906	1903	1905	1906	1908	1905	1905	1907	1905	1907	1903	1905	1906	1906	1904-6	1907
Simple or compound	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Comp.	Simple	Simple	Simple	Simple
Tractive effort, lbs	54,100	49,690	45,677	46,500	45,700	42,600	44,000	41,100	43,299	43,300	42,000	44,100	42,500	37,300	44,100	39,600	36,800	34,000
Weight, total, lbs	260,100	246,500	232,500	230,000	220,000	214,500	212,400	208,500	208,000	207,000	204,470	203,600	202,600	201,500	201,330	198,600	186,200	163,390
Weight on drivers, lbs	232,700	217,500	207,000	203,000	198,000	189,600	183,200	185,900	187,000	182,000	181,170	182,000	179,200	174,000	186,330	177,300	163,700	143,290
Weight on trucks, lbs	27,400	29,000	25,500	27,000	22,000	24,900	29,200	22,600	21,000	27,000	23,300	21,600	23,400	27,500	15,000	21,300	22,525	20,100
Weight, tender loaded, lbs	161,900	152,400	149,600	148,000	140,500	.....	175,200	143,500	135,050	148,000	143,000	146,400	150,200	116,900	.....	140,300	121,400	119,610
Wheel base, driving	17′ 0″	17′ 0″	17′ 6″	17′ 3″	17′ 6″	15′ 9″	15′ 6″	16′ 8″	15′ 8″	16′ 0″	16′ 3″	16′	15 8″	17′ 0″	15′ 8″	17′ 0″	15′ 10″	16′ 0″
Wheel base, engine	26′ 6″	25′ 11″	26′ 5″	26′ 5″	26′ 5″	24′ 6″	24′ 6″	25′ 7″	24′ 4″	24′ 4″	34′ 9″	24′ 3½″	24′ 6″	25′ 11″	24′ 4″	26′ 0″	24′ 4½″	24′ 3½″
Wheel base, engine and tender	60′ 10″	57′ 7½″	60′ 9½″	57′ 9¾″	60′ 3¾″	57′ 10½″	58′ 5″	59′ 8¼″	55′ 11¾″	56′ 3″	58′ 1½″	56′ 7¾″	69′ 1½″	55′ 8½″	57′ 11½″	58′ 0″	53′ 4¼″	53′ 9″
Diameter of drivers	63″	57″	63″	58″	63″	58″	57″	60″	57″	57″	56″	56″	57″	63″	57″	63″	57″	56″
Cylinders, number	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Cylinders, diameter and stroke	28″ × 32′	23″ × 30″	23″ × 32″	23″ × 30″	23″ × 32″	22″ × 30″	24″ × 32″	22″ × 30″	22″ × 30′	22″ × 30″	22″ × 28″	22″ × 30″	22″ × 28″	23″ & 35″ × 34″	22″ × 30″	23″ × 30″	21″ × 28	20″ × 28″
Valve gear, type	Wals.	Wals.	Wals.	Steph.	Steph.	Steph.	Wals.	Steph.	Steph.	Wals.	Wals.	Wals.	Steph.	Steph.	Steph.	Wals.	Steph.	Steph.
Steam pressure, lbs	160	210	200	200	200	200	160	205	200	200	205	200	210	210	200	185	200	200
Boiler, type	Str.	Wooten	Rad. stay	W. T.	Str.	W. T.	Str.	Str.	Str.	Str.	Belp.	Str.	Str.	E. W. T.	Str.	E. W. T.	E. W. T.	W. T.
Boiler, smallest diameter	84″	83¾″	81⅝″	80″	80″	77″	78¾″	74′ 5″	80″	78″	71″	76¹¹⁄₁₆″	79½″	67¾″	80″	74″	69″	61″
Boiler, height center	120″	113″	118¼″	119½″	117″	.....	114″	118″	114″	115½″	108¼″	114⅞″	115″	115″	.....	117″	111½″	105⅜″
Heating surface, tubes, sq. ft	3,931	3,716	3492.18	3,725	3,600	3,053	2,773	2630.1	3,226	2,939	2675.9	3,051	3511.56	2407.5	2,927	2,427	2,216	2069.3
Heating surface, firebox, sq. ft	198	329.5	213.05	232	182	192	157	179.3	177	183	166.5	175	221.77	158.	214	168	165	140.
Heating surface, total, sq. ft	4,129	4045.5	3705.23	3,957	3,782	3,245	2,930	2809.4	3,403	3,122	2842.4	3,226	3733.33	2565.5	3,141	2,595	2,381	2209.3
Heating surface, superheater, sq. ft	834	.....	.....	.....	.....	.....	600	.....	.....	.....	.....	.....	.....	261.4	.....	.....	375	.....
Grate area, sq. ft	60.2	99.85	56 5	55	55.4	50.4	47.4	56.24	49.5	51	49.11	54	54.2	46.8	33.6	50	43	44
Firebox, length	120″	126⅛″	108⅛″	108″	106″	108⅛″	95½″	107⅝″	108″	108″	107″	108″	108¾″	96⅛″	121″	107″	96⅝″	96⅛″
Firebox, width	72¼″	114″	75¼″	73¼″	75¼″	67¾″	71¾″	75¼″	66″	68″	66″	71¾″	72″	70¼″	40″	67⅛″	65¾″	66″
Fuel, kind	Bit. coal	Anth. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Oil	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal
Tubes, number firetube	472	493	446	461	446	360	355	282	413	386	373	403	450	224	390	340	244	283
Tubes, number superheater	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	40	.....	.....	22	.....
Tubes, diameter, firetube	2″	2″	2″	2″	2″	2¼″	2″	2¼″	2″	2″	2″	2″	2″	2″	2″	2″	2″	2″
Tubes, diameter, superheater	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3½″	.....	.....	5″	.....
Tubes, length	16′	14′ 6″	15′	15′ 6⅛″	15′ 4¾″	14′ 6″	14′ 11″	15′ 10″	15′	14′ 6½″	13′ 8½″	14′ 6½″	15′	15′ 9″	14′ 5″	15′ 6″	14′ 1⅛″	14′ 8″
Tender, coal capacity, tons	15	14	12	16	13½	.....	3,300 G	15	14	12	13½	12½	14	10	14	12	10	8
Tender, water capacity, gals	9,000	7,800	7,500	7,500	7,000	8,000	8,500	7,000	7,000	7,500	7,000	7,500	8,000	6,000	8,000	7,000	5,000	6,000
Weight on drivers ÷ tractive effort	4.3	4.37	4.5	4.37	4.3	4.44	4.17	4.5	4.3	4.2	4.3	4.13	4.2	4.65	4.2	4.5	4.4	4.2
Weight, total ÷ tractive effort	4.8	4.97	5.0	4.95	4.8	5.	4.75	5.1	4.8	4.76	4.8	4.61	4.8	5.4	4.55	5.	5.1	4.8
T. E. × diam. drivers ÷ total H. S	825.	700.	775.	680.	760.	760.	855.	875.	725.	790.	830.	768.	650.	830.	800.	965.	800.	860.
Total heating surface ÷ grate area	68.50	40.5	65.8	72.	68	64.	62.	50.	69.	61.	58.	59.80	69.	55.	93.	52.	55.	50
Firebox heat. surf. ÷ total H. S. %	4.80	8.12	5.75	5.85	4.82	5.9	5.35	6.35	5.2	5 85	5.9	5.42	5.9	6.15	6.8	6.5	6.9	6.3
Weight on drivers ÷ total heat. surf	56.	53.5	55.8	51.2	52.	58.	62.50	66.	55.	58.2	63 5	56.40	48.	48.7	59.5	68.	69.5	65.
Weight total ÷ total heating surface	63.	60.8	6.25	58.	58.	66.	72.50	74.	61.	66.	72.	63.	54.	56 5	64.	77.	78.	74
Total H. S. ÷ superheating heat. surf.	5.	.....	.....	.....	.....	.....	4.90	.....	.....	.....	.....	.....	.....	9.85	.....	.....	6.35	.....
Cylinder volume, cubic feet	22.70	14.4	15.4	14.4	15.4	13 2	16.80	13.2	13.2	13.2	12.4	13.20	12.4	11.4*	13.2	14.4	11.2	10.2
Total heating surface ÷ cyl. volume	181.	280.	242.	275.	246.	246.	174.50	213.	259.	236.5	229.	244.06	302.	312.	238.	180.	213.	217.
Superheating heat. surf. ÷ cyl. vol.	36 8	.....	.....	.....	.....	.....	35.5	.....	.....	.....	.....	.....	.....	23.	.....	.....	33.3	.....
Grate area ÷ cylinder volume	2.65	6.92	3.66	3.8	3.6	3.8	2.82	4.3	3.75	3.87	3.95	4.10	4.4	4.1	2.55	3.48	3.8	4.3
Reference in THE AMERICAN ENGINEER	1907 p. 302	1907 p. 22	1906 p. 263	1903 p. 415 1904 p. 11	1906 p. 73	.....	1908 p. 112	1906 p. 31	1905 p. 154	1907 p. 194	1906 p. 231	1908 p. 26	1903 p. 48	1905 p. 150	.....	1907 p. 147	1906 p. 165	1907 p. 31

*= Equivalent simple cylinders.

MASTER CAR BUILDERS' ASSOCIATION

FORTY-SECOND ANNUAL CONVENTION.

The first session of the 42nd annual convention of the Master Car Builders' Association was called to order on Young's Million Dollar Pier at Atlantic City, on June 17, 1908, the president, George N. Dow, being in the chair. Following a prayer by the Rev. Newton D. Caldwell, the Hon. F. P. Stoy, mayor of Atlantic City, welcomed the association in a brief address, to which reply was made for the association by Eugene Chamberlain.

The address of the president drew attention to the work which the present convention should attend to, as well as indicated general lines of progress that should be followed in the future. He stated that the two great objects of the association were, first, to promote uniformity in car construction and, second, to secure the most economical results in the interchange of traffic between the railroads of the country. These are so closely related as to compel the careful observance of the standards of the association if the best results are to be obtained in interchange. He drew attention to the careful scrutiny which the standards of the association are being given by the operating officials and to the great importance that they should be given the very closest attention. Some of the recommendations which the president wished to draw to the attention of the members are best given by quotations from his address as follows: "The necessity for co-operation and co-ordination of the work of the various railway associations has led the American Railway Association to propose changes in its organization which will admit of more harmonious relations between the various railway associations, and at the same time tend to centralize the recommendations for authoritative action with that association. In view of the nature of a great deal of the work of the Master Car Builders' Association, it is important that this association co-operate to the fullest extent with the American Railway Association, and in order that this may be accomplished some change in the constitution and by-laws of the Master Car Builders' Association will be necessary.

"The constitution at the present time does not provide for filling vacancies which may occur in the office of the president and vice-president or members of the executive committee, except by election at the convention, nor is it required that these officers of the association and members of the executive committee should actually be engaged in the railway service. I would therefore recommend that the constitution be changed to cover these points, after the subject is given full consideration by the proper committee.

"In the past, a large list of subjects has been referred to the association, and in the future, I would recommend reducing the list so as to give better opportunity to investigate and discuss the subjects more thoroughly.

"The adoption of a standard M. C. B. coupler. Several years ago an ineffectual effort was made in that direction. I believe the time is now ripe for such action.

"There has been a steady increase in the use of steel in car construction. The steel car has come to stay and I believe this association should give attention to this important matter to the end that its use may be extended more and more. I would recommend the appointment of a committee on standard steel shapes.

"Several years ago the question of the adoption of standard dimensions for the box car recommended by the American Railway Association was considered, and a system of framing only was accepted. The question was not given the consideration it deserves and to my mind is one that should be revived and studied to a conclusion. This subject at that time was referred to us by the American Railway Association, and we should complete our work and carry out the instructions given us. The appointment of a committee on this subject should be considered by your executive committee."

The report of the secretary showed the total membership to be 726, of which 424 were active members, 275 representative, 13 associate, and 14 life members. The number of cars represented in the association was 2,283,330, an increase of 28,933 for the year. The report showed that during the year twenty-nine railroads and private car lines had signified their desire to become subscribers to the rules governing interchange of freight cars. Five railroads had also advised of their acceptance of the code of rules governing the interchange of passenger equipment. The dues for the year 1909 were fixed at $4.00 per vote.

The address of E. A. Moseley, secretary of the Interstate Commerce Commission, received the closest attention. Mr. Moseley drew attention to the new employer's liability law passed by the recent Congress, which greatly increases the financial responsibility of interstate carriers to their employees and makes it necessary for them to exercise the greatest care in the employment of men, as well as in keeping all equipment in proper repair.

Attention was drawn to a decision rendered in the Supreme Court, which held that the variation in the height of couplers is downward from 34½ in., so that draw-bars on standard gauge freight cars must not be higher than 34½, nor lower than 31½ in. to comply with the law. Another principle of fundamental importance in connection with this case was the decision, in unmistakable language, that the statute imposed upon common carriers the absolute duty of keeping their equipment in the condition required by law at all times and the exercise of reasonable care in this respect was no defence.

Mr. Moseley drew attention to the legislation now pending before the Congress which aims to make the standards of the M. C. B. Association for the protection of trainmen the law of the land. This goes to indicate the great importance of the standards of the association and emphasizes the care with which they should be adopted.

Prosecutions for the violation of the safety appliance law to the number of 2,260 were filed in court during the preceding year. Mr. Moseley stated that the general condition of equipment throughout the country now showed such marked improvement that he believed the time was near when these appliances would be kept in the best possible condition and that the necessity for prosecution would be eliminated.

Following this address, the secretary announced that the executive committee submitted to the association for approval for honorary membership, the name of A. G. Steinbrenner, who had been a member of the association since 1883. This membership was approved.

The secretary announced that certain proposed amendments to the constitution had been received and would be sent to the members before the end of the year. The chair was authorized to appoint a sub-committee of three members of the executive committee of the association to confer with the proper committee of the American Railway Association and report to the executive committee so that the recommendations as to changes in the constitution and by-laws, necessary to secure greater co-operation between the American Railway Association and other railroad associations, might be distributed to members before December 15, 1908.

REVISION OF STANDARDS AND RECOMMENDED PRACTICE.—The report of this committee was read by C. A. Seley in the absence of the chairman, T. S. Lloyd. The report was very complete and practically all of the recommendations of the committee were ordered to be submitted to letter ballot. In addition to these a suggestion by O. C. Cromwell in regard to the joining of the taper to the straight portion at the center of axles, which had been disapproved by the committee, was approved and ordered to be submitted to letter ballot. An appendix to the committee report, regarding the size of brake shoe hangers and the design

two apprentice instructors for 45 apprentices. The apprentices formed a club and during the past year held fourteen meetings at which papers on various topics were presented and discussed.

Mr. Thomas said that at the Topeka shops of the Santa Fe there were 163 apprentices. The instruction of these apprentices cost the company about 23 cents per day each. The average rate of pay for apprentices is about $1.35 a day, bringing the cost of wages and instruction to about $1.60 per day. The average apprentice does about 80 per cent. as much work as the average journeyman. As a result of the apprentice system a higher class of boys are entering the service and are not only doing more work, but a higher grade of work, than under former methods.

Mr. Manning stated that on the D. & H. they had an apprentice instructor for mathematics and drawing and two demonstrators in the shop. Splendid results are being obtained. Mr. Manchester advocated giving the apprentices roundhouse training. Mr. Quereau strongly advocated having some one whose entire duty was to look after the apprentices, as it is only in this way that the best results can be obtained. Mr. Vauclain said that for the past seven years the apprentices of the Baldwin Locomotive Works had been in charge of a superintendent of apprentices and that the result was that they do not have to go outside to hire skilled men, but have more than they can make use of, and these men are eagerly sought for by other concerns. The Baldwin Locomotive Works has three grades of apprentices, those with a common school education, those from the high or preparatory schools and those from technical institutions. Mr. Basford emphasized the fact that the committee does not intend, in its recommendations, that the shop instructor should teach in detail all the trades represented in the shop, but that it is his business to see that the trades are properly taught. Upon motion by Mr. Vaughan the principles recommended by the committee were adopted as recommended practice and substituted for the code of apprenticeship rules adopted in 1898.

Co-operation of the American Railway Association.—The following resolution was adopted: "Whereas, A sub-committee of the American Railway Association has made certain recommendations looking to the co-ordination of the work of the voluntary railway associations with that of its own, be it

"Resolved: That the president of this Association be empowered to appoint a committee from its officers to confer with the American Railway Association when requested." On motion this resolution was adopted.

Superheating.—After reading the report Mr. Vaughan stated that he wished to modify the figures in Table No. 3, in which the G2 engine superheaters are shown to have burned 66 and 64 per cent. of the coal used by simple engines. It had been found that the simple engines were as a rule used on lighter and faster trains than the superheaters and a good deal of the saving was possibly due to that fact. This does not affect the rest of the table. He also stated that eight or nine months ago he was a little in doubt on the superheater question, as there had been a number of failures. During the last six months this had been overcome by systematic attention in the roundhouse and by periodic tests of the superheaters, and since the end of March there had not been a single superheater failure out of 200 engines thus equipped.

Mr. Muhlfeld suggested that the committee be continued to investigate the degree of superheat which would give the most economical results, and also as to whether it is advisable to use the products of combustion, or the waste gases, or a combination of the two, to produce superheat. In reply to this Mr. Vaughan called attention to the paper presented at the 1905 convention, in which proof was submitted that a high degree of superheat was desirable and that, although useless heat was rejected, it was more economical to reject that heat than to be without it.

Mr. Vauclain said that he had always felt that highly superheated steam was not what was wanted in this country, it being only desirable to have sufficient superheat to overcome all the loss of the single expansion locomotive and at the same time to make it possible to use a normal boiler pressure of 160 lbs. This would overcome the need for a compound locomotive or for any special appliances or special metal in connection with the use of highly superheated steam. It would also make it possible to produce a locomotive which would require even less attention than a single expansion locomotive. He called special attention to the service results which had been gained by engines with a low degree of superheat on the Santa Fe. Mr. Vauclain made it very plain, both at this time and in connection with the discussion of other reports, that he considered a simple engine equipped with a superhater, which would give a low degree of superheat, as the coming engine. Mr. Foster (L. S. & M. S.) spoke of the satisfactory service results which were being obtained from two superheater engines on the L. S. & M. S. The committee was continued and asked to report on the degree of superheat which will give the most economical results.

Mallet Compounds.—Mr. Vauclain advocated the use of front and back trucks on Mallet engines in order to be able to give additional boiler capacity. He also stated that it had been definitely demonstrated that Mallet engines are not so well adapted to mountain pusher service as to low grade service, although they are highly economical in mountain service. Mr. Mellin (American Locomotive Co.) is of the opinion that front and back trucks should not be used with this type of engine. The trucks elongate the leverages and the front truck is a great objection when the engine is backing.

Briquetted Coal.—Mr. Nelson called attention to the fact that with gas coals a maximum of 18 lbs. of water could be evaporated per square foot of heating surface and that in road service this figure is about 12 lbs. The evaporation of 19 lbs. with the use of briquettes is remarkable. Mr. Rosing stated that with the use of briquettes smoke was reduced 50 per cent. as compared with lump coal of the same grade and the throwing of cinders is reduced in about the same ratio. Several tons of briquetted coal which had been piled in the open air for three years showed scarcely any change.

Size and Capacity of Safety Valves.—Mr. Nelson said that the safety valves used on the boilers in the St. Louis tests had been calibrated; the record of the names of these valves had not been kept, but the average amount of water passed per second for all of the valves tested was 1.29 lbs. In a recent test to see what would be the condition of a locomotive running at about the capacity of the boiler, when suddenly shut off, it was found that the 4 in. safety valve, which was being used, passed 2.4 lbs. of water per second. The recommendations made in the minority report were adopted.

Balanced Compounds.—Mr. Vauclain in commenting on the report called attention to the fact that the percentages of economy per indicated horse power ranged from 38 to as high as 54.10. Mr. Clark said that the balanced compound engines in use on the C. B. & Q. were giving satisfactory results. The engines probably require a little more time in the roundhouse than the simple engines do, but they make good mileage with very few road failures. These engines do not disturb the track nearly as much as do the unbalanced engines. Mr. Vauclain said that although the compound engine was capable of hauling greater trains at higher speeds than single expansion locomotives, yet he was of the opinion that superheater engines possessed that faculty to about the same if not a greater extent than the compounds.

Topical Discussions.—Several of the topical discussions were omitted because of lack of time and the members who were to introduce these topics were requested to send their remarks to the secretary for publication in the proceedings. This is also to be done in connection with the individual paper on "The Training of Technical Men" by Prof. A. W. Smith, which was not received in time.

Revision of Standards.—The committee made a number of slight changes in the wording of the text of the standards and suggested that certain additional information be added to some of the tables of information; also that certain sections be changed to agree with M. C. B. standards. It was also recommended that the shrinkage of tires should be on a uniform proproportionate basis. These changes will be referred to letter ballot.

successfully completing the apprentice course. The entire scheme should be planned and administered to give these diplomas the highest possible value.

Seventh: Rewards in the form of additional education, both manual and mental, should be given apprentices of the highest standing.

Eighth: It is of the greatest importance that those in charge of apprentices should be most carefully selected. They have the responsibility of preparing the men on whom the roads are to rely in the future. They must be men possessing the necessary ability, coupled with appreciation of their responsibilities.

Ninth: Interest in the scheme must begin at the top, and it must be enthusiastically supported by the management.

Tenth: Apprenticeship should be considered as a recruiting system, and greatest care should be taken to retain graduated apprentices in the service of the company.

Eleventh: The organization should be such as graduated apprentices can afford to enter for their life-work.

For the purpose of obtaining data as to the conditions on various roads of the country, information was secured which is summarized as follows:

A shop plant for the purpose of this report is one in which general repairs of locomotives or cars are made. Fifty-five roads report 301 shop plants having apprentices and 67 plants in which there are no apprentices.

Fifty-five roads report a total of 7,053 apprentices in shop plants, distributed as follows:

Machinists	4814	Molder	82
Boilermakers	952	Electrician	14
Blacksmiths	311	Painter	137
Patternmaker	64	Upholsterer	27
Cabinetmaker	22	Carpenter	249
Tinner-pipefitter	365		

Reports from these roads show the average ratio of apprentices to mechanics in each trade to be as follows:

Machinists	1 to 4.8	Molder	1 to 8.2
Boilermakers	1 to 6.8	Electrician	1 to 8.6
Blacksmith	1 to 13.9	Painter	1 to 19.2
Patternmaker	1 to 8.3	Upholsterer	1 to 11.3
Cabinetmaker	1 to 23.3	Carpenter	1 to 72.4
Tinner-pipefitter	1 to 5.1		

The majority of replies indicate difficulty in securing apprentices in some of the trades, but no difficulty in others. A few replies state no difficulty in securing apprentices. This is apparently due to local conditions.

Of a total of fifty-five replies, ten, or 18.2 per cent., indicate that special instruction in trades is given apprentices. Forty-five replies, or 81.8 per cent., do not provide for special instruction.

Of a total of fifty-five replies, sixteen, or 29 per cent., indicate an established school system and thirty-nine, or 70.9 per cent., have no school system.

Of a total of fifty-five replies, thirty-nine, or 70.9 per cent., have apprentices and no school system, and eight roads state that they intend to establish such a system.

Eighteen replies favor day schools and three, or 14.3 per cent., favor night schools out of a total of twenty-one replies.

Fifteen replies show thirty-seven schools with 1,567 apprentices attending. The majority of the schools were recently established. Of these schools, twenty-eight are held in working hours and nine are held in the evening.

Of the above schools, thirty-four are compulsory and three are optional.

Of the fifty-five roads, twelve pay the apprentices for time spent in school.

Modern apprenticeship training has been introduced in seventeen shops on four roads with 506 apprentices since the convention of June, 1907. The following roads and systems of roads have made substantial progress in this work.

			No. Apprs.	Estab.
Union Pacific	1 school.	Omaha	71	9-1-06
	1 school.	Cheyenne	21	12-1-07
Michigan Central	1 school.	St. Thomas	36	12-1-07
Santa Fe	10 schools.		363	1908
Southern Railway	1 school.	Knoxville, Tenn.		1907
	1 school.	Spencer, N. C.		1907
Delaware & Hudson	3 schools.	Green Isle, Oneonta, Carbondale	86	1907

Substantial progress has also been made on roads having schools previously established, on the Grand Trunk Ry., Central R. R. of N. J., Boston & Maine R. R., Union Pacific R. R., Minneapolis, St. Paul & Sault Ste. Marie R. R. and New York Central Lines.

The Canadian Pacific R. R. and the Erie R. R. advise that they intend to install the improved plan of apprenticeship during the present year. Other important roads have the subject under contemplation.

The committee recommends that the Association provide an appropriation for establishing an exhibit of apprentice training to be a feature of each convention.

It has often been said that apprenticeship is a thing of the past. This certainly is not true of American railroads to-day, where a new apprenticeship has sprung up and has attained a healthy growth with brightest promise for the future. The committee does not hesitate to characterize the new apprenticeship as the most important influence introduced into railroad organizations during the present generation. This development is sure to be rapid, requiring great wisdom, combined with conscientious and systematic efforts in its control. We believe this movement will become the most powerful influence in supplying and preparing the men of the future for the motive power departments (and perhaps other departments) of American railroads; because the movement trains men in the ideal way, and because men properly prepared for their work constitute our greatest problem to-day.

An appendix to the report, prepared by W. B. Russell, gives a summary of the recent progress of apprentice training in England.

Best System of Washing Out and Refilling Locomotive Boilers.

Committee—H. T. Bentley (chairman), L. H. Turner, S. K. Dickerson, M. E. Wells, H. E. Passmore.

The best system of washing out is one that will do the work properly, with the least change in temperature in boiler, at a minimum expenditure of heat, and in the shortest possible time.

The fact that good results are obtained by having less trouble from fire-box and flue leakage, and a reduction in the number of stay-bolt breakages, and last, but not least, the reduction in terminal delays, would appear to warrant the expense of installation. The more nearly uniform the temperature is kept, the less expansion and contraction takes place, especially in the fire-box, which must reduce the vibration in stay-bolts and give them a correspondingly increased life. It has been demonstrated beyond a doubt that when a boiler is kept at a uniform temperature, the least trouble is experienced in the matter of leaking flues and fire-boxes.

In taking the question up with a number of superintendents of motive power, who are using various devices having the object of washing out, changing water and raising steam quickly, by the use of hot water, and live steam where necessary, the following information was gathered:

There are four or five different systems which have been in use from one to three years.

They cost from $5,500 to $20,000, depending on size and number of stalls equipped, which at 5 per cent. interest would mean an expense of from $275 to $1,000 per year.

The various systems reported are said to be entirely satisfactory; then can wash out and get ready for service twenty to twenty-six engines per twenty-four hours; the average time required to wash out and get an engine ready for service is from 55⅓ minutes to 4 hours 15 minutes; the average time formerly taken was 3 to 6 hours.

In all cases a very marked reduction was reported in flue leakages and broken stay-bolts, although very little exact data were available on this subject. At one point it has been possible to reduce the number of boiler-makers employed from ten to four, due to decreased boiler work since the hot water washing-out system has been installed.

Some of the other benefits derived are given as follows: No evidence of steam in roundhouse; always plenty of water at 212 degrees to refill boilers; temperature of water reduces time and fuel necessary to get engine hot; facility in turning engines; reduction of engine failures, reducing overtime; reduction of time at terminals where washing out is necessary.

Probably the most important saving effected by the hot water changing or wash-out system, is the rapidity with which the work can be done; engines are ready for service from one to two hours quicker than could possibly be the case with a cold-water system, which necessitates cooling an engine down after the steam has been blown off, before the engine can be washed out, and then directly after bringing the water back to the high temperature; such waste of heat, which means coal, would not be tolerated under any other conditions, but takes place daily at hundreds of roundhouses in this country, without any protest.

A simple arrangement used on one of the Western roads with very great success, for utilizing steam and water otherwise wasted, is to have wells into which cold water flows from the main, or source of supply, and to heat it by steam and hot water from engines; from this place the water is pumped for washing out and filling boilers. This is probably the cheapest system for furnishing hot water, but has the objection that the water has been blown from dirty boilers; however, as only a boilerful is taken, it is soon diluted and rendered innocuous by the fresh water injected into it from the tank.

The following actual savings have been reported:

Decreased cost of washing boilers. In 1906 with cold water, for labor alone it cost $1.32 per boiler, whereas, with hot water in 1907, $1.01 was charged against this item, or on the road reporting it, a saving of $2,019.95 per year for labor alone, in washing boilers, was effected on an outlay of $6,000.

Decreased cost of water used. This item may not appear at first sight to amount to much, but where a saving of 7,000 gallons for each boiler washed out can be effected, as has been reported.

and experiments were made with the percentage of binder from 5 per cent. to 8 per cent. All tests were run on the locomotive testing plant, a simple cylinder Atlantic type locomotive being used, having a total heating surface including fire side of tubes of 2,320 square feet and a grate area of 55.5 square feet.

The series with the raw coal was run in such a way as to show the full performance of the boiler from low rates of evaporation to the highest possible rate of evaporation. The lowest rate of evaporation was about 18,000 pounds of water per hour, equal to 8 pounds per square foot of heating surface; this being increased throughout the test until, with the briquetted fuel, an evaporation of 44,500 pounds of water from and at 212° F. was obtained. This is equivalent to 19 pounds of water per hour per square foot of heating surface. The briquettes were fired with ordinary shovel and handled in the manner usually employed for coal, no necessity being found for breaking them.

The following table taken from a plot of actual results shows comparatively the evaporation of the natural and briquetted coal.

When the rate of evaporation per square foot of heating surface is, pounds.	The equivalent evaporation per pound of fuel is, for	
	Natural Lloydell coal, pounds.	Briquetted coal, pounds.
8	9 5	10.7
10	8.8	10.2
12	8.0	9.7
14	7.3	9.2
16	6.6	8.7

The quantity of cinders collected in the smoke box showed no material difference as between the raw coal and the briquetted coal. The quantity collected per hour when burning 100 pounds of fuel per square foot of grate was about 400 pounds, reaching a maximum of about 750 pounds per hour with the coal being burned at the rate of 120 pounds per square foot of grate. Firebox and smoke-box temperatures were practically the same at the same rates of evaporation, whether the coal was used in its raw state or briquetted.

The apparent reason for the increased evaporation per pound of fuel with the briquetted coal is that, although, as already stated, the loss due to cinders in the smoke box is not different as judged by the quantity collected, the calorific value of the cinders from the briquetted coal was lower than with raw coal, and, further, on account of the uniform size of the briquetted fuel the distribution of air through the fire permitted more complete combustion and liberation of heat than with the raw coal.

The fuel consumed per draw-bar horse-power with the locomotive running at a speed of 37.78 miles per hour and a cut-off of 25 per cent. was as follows:

Raw coal	4.48 pounds
Round briquettes	3.65 pounds

This is equivalent to stating that the amount of briquetted coal was 81 per cent. of the amount of raw coal required per draw-bar horse-power at this speed and cut off.

Smoke observations were made by Ringelmann's method and by photographs. By this former method no smoke is indicated by 0 and very black smoke by 5, there being a total of six gradations from 0 to 5 inclusive. The following table indicates for a portion of the speeds and cut-offs the comparative smoke readings, these being an average of a large number of observations made at regular intervals.

Speed, miles per hour.	Cut off.	Average smoke.	Kind of fuel.
	Per cent.		
28.34	20	1.2	Raw coal.
28.34	20	0.8	Round briquettes.
37.78	25	1.8	Raw coal.
37.78	25	0.7	Round briquettes.
37.78	30	2.1	Raw coal.
37.78	30	1.8	Round briquettes.

It is evident from the above that the briquetting of this coal materially reduced the amount of smoke, but it could not be determined whether the difference in percentages of binder used made any difference in the smoke produced.

At the end of one test at about 37 miles per hour and a cut-off of 32 per cent., the locomotive was shut off and the blower put on and at the end of two minutes the smoke had entirely cleared from the stack. Various supplemental tests indicated that with care the locomotive could be brought into a terminal where smoke was objectionable by the proper use of blower and judgment on the part of the engineman in regard to the amount of fuel in the shape of briquettes fed to the fire. There was no difficulty in starting the fire with briquettes, the same method being used as with the raw coal.

To determine the effect of weathering, a number of round and square briquettes were placed on the roof in January and February and examined in May or about four months after, and these showed no change whatever in their condition.

For these tests, the briquettes which had been made at the station of the Geological Survey were shipped to Altoona carefully stacked in open gondola cars and were carefully unloaded and restacked. Very few were broken and the amount of fine coal abraded from the surface was practically negligible. This method of handling was all carefully done, but if the briquettes had been shipped for regular locomotive service it is not thought that the breaking and abrasion, due to handling briquettes, would be a serious matter for regular service.

Subjects.

Committee—C. A. Seley (chairman), D. F. Crawford, L. R. Pomeroy.

The committee suggests the following subjects for committee work for the 1909 convention:

1. The organization best suited to obtain economical results in maintenance of locomotives. Le Grand Parish, H. D. Taylor, D. J. Redding, A. Forsythe, S. J. Hungerford, H. W. Jacobs.

2. Driving pressure for firebox rivets and the advantage of avoiding seams in locomotive crown sheets. W. F. Kiesel, J. H. Manning, W. A. Robb, H. H. Maxfield, G. Wagstaff.

3. Use of plug and ring gauges for all important fits. R. N. Durborow, A. Stewart, L. H. Turner, H. B. Ayres.

4. Ash pits and ash handling plants; the best and most efficient arrangement. H. S. Hayward, W. Manchester, F. H. Clark, John Howard, H. M. Curry.

5. Rolled steel wheels. A. S. Vogt, H. Bartlett, J. E. Muhlfeld, C. H. Quereau, G. W. Wildin.

6. Standard rules for testing boilers and stay bolts. J. T. Wallis, T. A. Foque, M. E. Wells, M. H. Wickhorst, W. C. A. Henry.

7. Standard limits governing the wear of locomotive tires, as concerns height and thickness of flange and depth of channeling. E. D. Bronner, Robt. Quayle, R. K. Reading, C. E. Fuller, J. T. McGrath.

8. Advantages of water purification as a means of decreasing cost of locomotive repairs and reducing failures on the road. W. C. Arp, H. Stillman, G. H. Emerson, R. D. Smith, E. B. Thompson.

9. Investigation as to the most desirable composition of material for locomotive driving wheel tires, and adoption of standard grades for various classes of service. T. W. Demarest, W. R. McKeen, J. A. Carney, W. A. Nettleton, F. M. Whyte, C. B. Dudley.

INDIVIDUAL PAPERS.

1. Heat transference of tubes and plates. Prof. Charles Edward Lucke, Columbia University.

2. Crane hooks; results of exhaustive experiments and recommendations as to design. Prof. Walter Rautenstrauth, Columbia University.

VALUE OF SPECIFICATIONS TO PURCHASING AGENTS.—Many purchasing agents spend half their time trying to secure further definite information than is ordinarily furnished at first in regard to supplies they are asked to buy. They do this in order to have some specifications, even though crude, as a fair basis on which to compare bids and place orders, which will insure to some extent the railroad company's receiving the quality, sizes and kinds of supplies best suited for its requirements. If, therefore, a purchasing agent is supplied with definite and complete specifications and drawings prepared by experts, covering many of the most important articles purchased, the result is certainly a great relief to the purchasing department. It simplifies the work there, not only at the time purchases are made, but later also in lessening the amount of correspondence complaining about defective devices or inferior workmanship or material.—*W. V. S. Thorne before the New York Railroad Club.*

THE VALUE OF OUR MANUFACTURED PRODUCTS.—In 1905 the value of the product of our manufactures amounted to $16,866,706,985; the total receipts of the steam railroads were $2,325,765,167. In manufacturing, the value of the product was $1,152 for each horse-power installed and the yearly wages amounted to $248 per horse-power. In the railroad industry, the gross receipts amounted to $555 and the yearly wages to $224 per horse-power, rated on a basis comparable to that used in the census report covering manufactures.—*H. St. Clair Putnam before the Conference on the Conservation of Natural Resources.*

MASTER MECHANICS' ASSOCIATION

ABSTRACTS OF COMMITTEE REPORTS AND INDIVIDUAL PAPERS (*Continued from Page 281*).

Mallet Articulated Compound Steam Locomotives.

Committee—J. E. Muhlfeld, chairman; G. H. Emerson, T. Rumney, F. H. Clark, C. J. Mellin.

The committee appointed to report on this subject submits the following conclusions, which are based on a comparison of the Mallet articulated compound types of steam locomotives now operating on American railways in road and helper freight service with other designs of steam and electric locomotives performing similar work under relative fuel, water and climatic conditions.

First: That for the greatest permissible tonnage and speed per train, on lines of considerable gradient and curvature, the Mallet articulated compound types of steam locomotives, either with or without leading and trailing trucks, and ranging in tractive power of from 55,000 to 125,000 pounds, are relatively lower in first cost and, from performance to date, are more efficient and economical in operation and maintenance per unit of tractive power developed.

Second: That the Mallet articulated compound types of steam locomotives enable a practical improvement in the boiler efficiency by means of greater boiler capacity, increased reserve steam and water storage, larger grate area and fire-box and tube heating surface, prolonged passage of the products of combustion through the boiler, quickened circulation of the water in the boiler, heated feed water and reduced rate of draft and combustion.

Third: That the Mallet articulated compound types of steam locomotives give the practical opportunity to improve the engine efficiency by means of relatively greater tractive effort per pound of adhesive weight and from superheated higher initial, reheated receiver and lower terminal working steam pressure due to the greater ratio of expansion that can be obtained in the cylinders as well as through the use of a large intermediate receiver capacity, which is made possible by the four independent cylinders and their supply steam connections.

Fourth: That the Mallet articulated compound types of steam locomotives should have less depreciation, wear and failure of boiler and machinery through increased reserve capacity, reduced pressure of exhaust steam, more flexible wheel base, subdivision of power and stresses over a greater number of frames, cylinders, pistons, axles, crank pins, rods and auxiliary parts; better balancing of the reciprocating and revolving mechanism, more uniform turning moment and less slipping of driving wheels.

Fifth: That the Mallet articulated types of steam locomotives having relatively less non-adhesive weight per driving wheel and a more uniform turning moment with a reduction in unbalanced pressure at the driving wheel and rail contacts, resulting in maximum adhesion, minimum slipping and a distribution of weight over a short rigid combined with a long flexible wheel base, will materially reduce the bridge, tie and rail strains and the tie and rail wear per unit of tractive power developed.

Sixth: That the Mallet articulated types of steam locomotives either for road or helper freight service can materially increase the capacity of a given piece of track by fewer train movements and less congestion at terminals without increasing the acceleration or running speed above that which is permissible for efficient and economical heavy tonnage train movement, proper working super-elevation of curves, minimum rail wear and the least liability for derailment or accident.

Seventh: That the Mallet articulated compound types of steam locomotives will particularly place the movement of the traffic under the control of fewer persons; lessen the liability for complete disablement and reduce the cost for engine and train crew hire, fuel, water, lubricants, stores, wiping, hostlering and dispatching.

Eighth: That the non-paying weight in motive power and supplies and the retarded movement and stalling of heavy tonnage trains will be minimized by the Mallet articulated types of steam locomotives, especially through exceptionally long tunnels where the permissible reversing of this type of locomotive will not subject the crews to the gases, smoke and heat from the exhaust.

Ninth: That the use of the Mallet articulated compound types of steam locomotives may permit of maintaining or progressively increasing the average gross tonnage per successive train movement between terminal yards to that which, consistent with the balancing of the motive power, distribution of cars and the accumulation of the traffic on the divisions, might give the desired capacity as well as efficiency and economy in the operation of a single piece of trunk-line track and its terminals without making an expenditure on roadway to increase the weight limit or for a reduction of grade, curvature or distance that would otherwise be necessary to accomplish the same result.

Tenth: That for service where it is essential to increase the tons moved per mile per hour per unit of cost by developing greater tractive power in one locomotive than what can be efficiently and economically produced by a consolidation or similar type and where the use of self-contained motive power, proportion of adhesive to total weight, center of gravity, distribution of weight over driving wheels, driving wheel load, flexibility of driving wheel base, and particularly the first cost, fixed charge, operating expense and reliability of service are elements of importance, the use of the Mallet articulated compound types of steam locomotives should receive careful consideration.

RESULTS IN SERVICE.

Baltimore and Ohio Railroad Performance.—The first locomotive put into operation in this country was for the Baltimore & Ohio Railroad, its object being to determine upon the practicability of such a class of motive power to efficiently and economically increase the capacity of a busy, mountainous line in event that might become necessary. The design of the experimental locomotive decided upon was of the Mallet articulated duplex compound steam type, and the construction was completed in April, 1904, after which the locomotive was exhibited at the Louisiana Purchase Exposition, and later put into regular helper freight service on the Connellsville Division on January 6, 1905.

The following data are self-explanatory and show the actual results from the performance of this locomotive for the three and one-third year period ending May 5, 1908:

	Freight Service		
	Road	Helper	Total
Engine crew or constructive mileage (on basis of 6 miles per hour)	1,798	139,104	140.902
Locomotive or actual mileage	1,798	76,601	78,399
Time available for Transportation Department use	1,027 days, or 84.5 %.		
Time unavailable for Transportation Department use	189 days, or 15.5%.		
Water used per pound of coal consumed	6.23 pounds.		

COST IN CENTS PER MILE RUN.

For	On Basis of	
	Const'ctive Mileage	Actual Mileage
Engine crew hire	10 16	18.27
Fuel	9.30	16.71
Repairs	4.96	8.92
Wiping, hostlering and dispatching	.89	1.60
Lubricating oil, grease and waste	.51	.91
Water	.45	.82
Sand, illuminating oils and other supplies	.29	.51
Total cost	26.56	47.74

The actual mileage includes only the road miles made by the locomotive and does not provide for the time that it was crewed and waiting for trains, working around terminals and switching, a considerable proportion of which occurs in helper freight service and for which an allowance is made in the constructive mileage.

The following essential features, which were somewhat radical as compared with the ordinary American railroad practice at the time this locomotive was designed, have given entirely satisfactory results: Articulated frame; elimination of truck wheels; Mellin system of duplex compounding and simpling; flexible joints to the receiver and exhaust pipes; Walschaert motion gear; combination hand and power reversing gear; high pressure piston and low pressure double-ported slide valves; high and low pressure steam balanced piston packing rings; method of securing high pressure cylinders to boiler; single disk balanced main throttle valve and 235 pounds working steam pressure.

No difficulty has been experienced with the tracking and riding qualities going forward or backward, around maximum curvature or on straight track, either when pushing, pulling or breaking trains or running light. The performance has demonstrated that neither leading nor trailing truck wheels are neces-

From the performance to the present date it is thought that a considerably lower ratio of adhesion is permissible with the Mallet type locomotives as compared with other classes.

Design.—The question of flange wear was carefully considered due to the fact that the locomotives would be required to operate in both directions without turning. It was decided to provide leading and trailing wheels in combination with radial trucks and the results have been very satisfactory.

Maintenance.—The cost for repairs per mile run will necessarily average higher than for the simple consolidation locomotives, but on the basis of 100-ton miles it is materially reduced.

While no trouble has been experienced in keeping the flexible low-pressure steam and exhaust pipe joints tight they have required considerable attention and consideration is now being given to the use of a metallic packing.

On the first locomotives built the high-pressure cylinder saddles were secured to the boiler shell by means of studs, which caused considerable trouble due to their working loose and leaking. This difficulty has been overcome by the use of cast-steel cylinder saddles, which are riveted to the boiler shell.

During the winter months some trouble was experienced through having to keep the cylinder cocks open to relieve the condensation due to the low pressure steam coming in contact with the low pressure cylinder large wall area. It is the opinion that the use of some form of reheater or superheater would overcome this difficulty and bring about a considerable improvement in the efficiency.

On account of the trouble experienced in supplying sand to the rail ahead of the first driver wheels to the low-pressure or articulated engine, it was found necessary to locate an independent sand-box between the cylinders of the low-pressure engine, and which has overcome the difficulty due to the original sand-box location on top of the boiler.

The foregoing information is self-explanatory as to the results that have been obtained from the use of these locomotives, and justifies the general conclusions as set forth in this report.

Northern Pacific Railway Performance.—The Northern Pacific Railway now has in helper freight service 16 Mallet locomotives of similar type to those in use for the same class of service on the Great Northern Railway. Two of these locomotives are now in use on the Cascade Mountain Lines, and from which operation it is expected to secure some valuable comparative performance data. While some weak points have developed in the operation and maintenance, more especially in connection with the flues, the locomotives in general are rendering good service and haul an increase of about 300 tons in train up a 2.2 per cent. grade as compared with the other heaviest types of mountain-locomotives in similar service on that railroad.

Chicago, Burlington & Quincy Railroad Performance.—The Chicago, Burlington & Quincy Railroad has had one of the Great Northern Line helper freight Mallet locomotives in their service for some time past and has recently put into use two additional locomotives of this type. To the present date the committee has been unable to secure any detailed information of the performance of these locomotives except such as pertains to the one Great Northern Line type, which is included in the tabulation, photogravure, diagram and profile sheet and comparative performance data compilation (not reproduced).

American Railroad of Porto Rico Performance.—Three of the four Mallet locomotives in use on this railroad operate between Mayaguez and Lajas to transport the sugar-cane traffic.

Two locomotives, each in service about sixteen hours, handle a total of ninety loaded cars, each of 15-tons capacity, every working day, while the third locomotive is retained in reserve.

From Mayaguez to Filial Amor the Mallet locomotives are assisted by one consolidation type to hasten the formation of the loaded car trains and to distribute empty cars. From Filial Amor to Lajas the loaded and empty movement is handled by the Mallet locomotive.

The fourth Mallet locomotive is in service on another section. The performance is satisfactory.

Miscellaneous Railway Performance.—With respect to the three Mallet locomotives in service on the Central Railway of Brazil, and the two on the Guayaquil & Quito Railway of Ecuador, the committee regrets that up to the present time it has been unable to secure any detailed data pertaining to their performance or maintenance. What information has been secured indicates that they are giving satisfactory results and are suitable for the purpose for which they were constructed.

Size and Capacity of Safety Valves for Use on Locomotive Boilers.

Committee—F. M. Gilbert (chairman), G. W. Wildin, J. H. Manning.

No uniform practice seems to have prevailed in the past in proportioning safety valves to the work they are to perform. The locomotive builders follow specifications of the railroad companies, and it seems to have been the practice of the railroad companies to base their specifications on what has been done before on similar locomotives. The various railroad companies have fallen into the practice of specifying so many 2½, 3, 3½ or 4-inch valves, which, when reduced to exact language, does not mean anything definite. Obviously, two 3-in. valves having a sustained lift of ⅛-in. have a greater capacity for the discharge of steam than eight 3-in. valves having a sustained lift of 1-32 in. each. The committee does not wish to convey the idea that the two 3-in. valves having a sustained lift of ⅛ in. are better for the boiler than eight 3-in. valves having each a sustained lift of 1-32 in. It simply wishes to point out the errors that may arise from the practice of specifying so many valves regardless of the sustained lift.

Perhaps the most important part of any investigation should be the determination of the proper amount of evaporation which the safety valves shall be called upon to relieve. We already have information as to the maximum evaporation of locomotives from the tests at St. Louis in 1904, but the committee feels that the safety valves would never be called upon to relieve this amount from the fact that the combustion in the firebox is stimulated by the exhaust, and that this exhaust is caused from the use of the steam in the cylinders, so that, at a time of greatest evaporation, the steam is being used approximately as fast as it is generated. Hence, it remains for the investigators to determine what shall be deemed the proper amount of relief in safety valves. Then, too, the lift of valves of various sizes at the different pressures must necessarily be determined, as also the effect of this lift on the life of the valve seats and the tendency the lift of the valves may have to raise the water in the boiler.

It is no less important that some data be collected on open and muffled valves, and in this connection, considering the tendency of the muffler to retard the flow of steam through the valve, it is of importance that we review the work of Mr. Brownlee on the flow of steam through an orifice, which is contained in a "Report on Safety Valves" in the transactions of the Institution of Engineers and Shipbuilders in Scotland, Vol. XVIII, 1874-75, page 13. In this report Mr. Brownlee has compiled some data on the rates of discharge under a constant internal pressure, into various external pressures, upon which D. K. Clark, in his work on the steam engine, bases the following statements: "The flow of steam of a greater pressure into a receiver of a less pressure increases as the difference of pressure is increased, until the external pressure becomes only 58 per cent. of the absolute pressure in the boiler. The flow of steam is neither increased nor diminished by the fall of the external pressure below 58 per cent., or about four-sevenths of the inside pressure, even to the extent of a perfect vacuum. In flowing through a nozzle of the best form, the steam expands to the external pressure, and to the volume due to this pressure, so long as it is not less than 58 per cent. of the internal pressure. For an external pressure of 58 per cent. and for lower percentages, the ratio of expansion is 1 to 1.624."

From the foregoing, one is led to believe that the muffler produces no appreciable retarding effect on the safety valve. The committee feels that this should be verified in present practice.

As stated, it is essential that the amount of evaporation that the safety valves should relieve be determined. This can best be determined by applying two safety valves of known diameters and lift, which, according to the empirical formula, are known to be a little small. A third valve, of a larger diameter and set to pop at a somewhat higher pressure than the smaller valves, should be applied as a means of protection. If at any time during the test the two small valves go into action and the boiler pressure rises above the popping point, it would be reasonable to assume that the valves were of insufficient capacity. Another trial with valves of a larger diameter would no doubt prove of sufficient capacity. By changes in this manner it would be possible to apply two valves of sufficient capacity, and the diameter, lift, and form of valve being known, it would be a simple matter to obtain the amount of evaporation that the valves were called upon to relieve on the particular type of locomotive in question. It is important in this connection that the observation of pressures be very accurate, and the committee would suggest that a pressure-recording gauge be attached to the boiler to serve as a check on the observer. Perhaps the most reliable method of determining the lift of the valves would be to attach a rod to the top of the valve stem. This rod could be connected to a lift-recording gauge and also to a lift-recording mechanism, operated by a small motor, which, while recording the lift on the card, would also record the time element. This mechanism would give an accurate check on the gauge observations. It is understood, of course, that the lift measurements be made in the shop.

During the past few months the committee has been collecting data from the various railroad companies in order to arrive at some definite conclusions regarding existing practices. A letter of inquiry was also addressed to the various valve manufacturers and to the locomotive builders. The replies from some twenty railroads show that the safety valves now in use are of sufficient capacity, and on these reports the committee has based the calculations that are to follow. The records from twelve important roads show that the lift of the valves varies from 1-32 inch to 1-10 inch.

Taking the mean effective area of opening in square inches

The committee, however, is impressed, with the possible saving in regular service of balanced compound locomotives, and this would undoubtedly be realized with other types of compounds, but as the results in actual service are those which must finally be depended upon for ultimate economy, the committee would recommend to the members of the association a careful record of performance, in order to determine how far the economy in fuel and water can be realized, when all factors are considered.

The analysis already given and prepared for the purpose of determining the question of costs of maintenance, as well as the comparative cost of fuel, apparently covers the points involved sufficiently, but as already stated, the committee could not secure this data covering a sufficient number of compound and simple locomotives to draw definite conclusions.

Some action of the association, which will secure the coöperation of railroads in preparing information on this basis for the next convention, might produce valuable comparisons. It is necessary to have these records of performance covering the period from the time the locomotive was built and placed in service up to and including the most recent data concerning its performance.

This would involve probably considerable work in going over old records, but if some satisfactory conclusions could be reached in regard to this matter on the basis of ultimate economy, a decided step forward would be gained in railroad operation.

PERSONALS.

R. E. Fulmer has been appointed master mechanic of the Tremont & Gulf Ry., with office at Eros, La.

A. C. Miller has been appointed master mechanic of the Texas Midland Ry., with headquarters at Terrell, Tex.

R. B. Smith has been appointed foreman of motive power and equipment of the Cincinnati, Lebanon & Northern Ry., at Pendleton, Ohio, succeeding John Stutter, resigned.

F. C. Pickard has been appointed master mechanic of the Mississippi Central and of the Natchez & Eastern Rys., with office at Hattiesburg, Miss., succeeding W. J. Haynen.

The resignation of A. Bardsley as master mechanic of the Gulf and Ship Island R. R. at Gulfport, Miss., which was mentioned in the July issue, was caused by ill-health.

J. J. Waters has been appointed superintendent of machinery of the Mexican Central R. R., with headquarters at Aguascalientes, Aguas, Mex., succeeding Ben. Johnson, resigned.

H. F. Grewe has been appointed general foreman of the mechanical department of the Wabash Pittsburgh Terminal in charge of locomotive work, with headquarters at Rook, Pa.

G. H. Davis, master mechanic of the Clarendon & Pittsford R. R., has been appointed general foreman of the car department of the Wabash Pittsburgh Terminal, with headquarters at Rook, Pa.

J. H. Gimpel, master mechanic of the Vera Cruz & Pacific Ry. at Tierra Blanca, V. C., Mex., has been appointed master car builder, with office at Tierra Blanca. R. Fitzsimmons succeeds Mr. Gimpel.

W. T. Fitzgerald, master mechanic of the Wisconsin & Michigan Ry., has resigned to accept service elsewhere, and his duties are assumed by S. N. Harrison, superintendent, the office of master mechanic being abolished.

A. J. Isaacs, foreman of locomotive repairs of the Chicago & Alton R. R. at Kansas City, Mo., has been appointed master mechanic of the Chihuahua division of the Mexican Central Ry., with headquarters at Chihuahua, Chih., succeeding S. E. Kildoyle, resigned.

Charles E. Fuller, assistant superintendent of motive power of the Union Pacific R. R., has been appointed superintendent of motive power and machinery, with headquarters at Omaha, Neb., effective July 20. Mr. Fuller succeeds Mr. W. R. McKeen, Jr., resigned.

W. R. McKeen, Jr., superintendent of motive power and machinery of the Union Pacific Ry., has resigned and will devote his entire time to the McKeen Motor Car Co., which is being organized by E. H. Harriman, Mr. McKeen and others to build gasoline motor cars for railway uses.

George Hackney, superintendent of machinery of the Atchison, Topeka & Santa Fe Ry. from 1877 to 1891, died at Topeka, Kan., on June 19, aged 82 years. Mr. Hackney was one of the pioneer railroad men of the West. He was born in England and came to America in 1853 and was at one time shop foreman for the Menominee Locomotive Works at Milwaukee, Wis., and also shop foreman of the Chicago, Milwaukee & St. Paul Ry. He was later master mechanic on the Chicago & North-Western and the Chicago, Milwaukee & St. Paul Railways.

George H. Daniels, formerly and for sixteen years general passenger agent of the New York Central, died at Lake Placid, N. Y., on July 1. Mr. Daniels was born in 1842 at Hampshire, Kane County, Ill. In 1857 he worked as rodman on an engineer corps of the North Missouri, now part of the Wabash, but his railroad career practically began in 1872, when he was appointed general freight and passenger agent of the Chicago & Pacific, now part of the Chicago, Milwaukee and St. Paul Ry. In 1880 he was made general ticket agent of the Wabash, St. Louis & Pacific, now the Wabash R. R. Two years later he became commissioner of the Iowa Trunk Line Association and also commissioner of the Colorado Railroad Association. In 1884 he was also made commissioner of the Utah Traffic Association, and two years later became commissioner of the Central Passenger Committee. The next year he was appointed assistant commissioner of the Central Traffic Association and chairman of the Eastbound Passenger Committee. In 1887 he was elected vice-chairman of the Central Traffic Association and chairman of the Eastbound Passenger Committee. In 1889 he was appointed general passenger agent of the New York Central & Hudson River R. R., and as the creator of the very efficient advertising department of that company became known throughout the world. He was relieved of the heavy responsibilities of the passenger department in 1905, and resigned in May, 1907.

ERRATA.—In the tabular comparison of recent locomotives, page 230 of the June, 1908, issue, will be found two typographical errors as follows: Under the head of Pacific type locomotives, the ratio, "T. E. x diameter drivers ÷ total H. S." for the Erie locomotives should be 699 instead of 669, as shown. Also the ratio of "Total heating surface ÷ cyl. volume" for the Baldwin balanced compound of the A. T. & S. F. Ry., shown in the eleventh column, should be 310. instead of 3.10.

FORESTS FAST DISAPPEARING.—The forests of this country, the product of centuries of growth, are fast disappearing. The best estimates reckon our standing merchantable timber at less than 2,000,000,000,000 feet. Our annual cut is about 40,000,000,000 feet. The lumber cut rose from 18,000,000,000 feet in 1880 to 34,000,000,000 feet in 1905; that is, it nearly doubled in 25 years. We are now using annually 500 feet board measure of timber per capita, as against an average of 60 feet for all Europe. The New England supply is gone. The Northwest furnishes small growths that would have been rejected by the lumberman thirty years ago. The South has reached its maximum production and begins to decline. On the Pacific coast only is there now any considerable body of merchantable standing timber. We are consuming yearly three or four times as much timber as forest growth restores. Our supply of some varieties will be practically exhausted in ten or twelve years; in the case of others, without reforesting, the present century will see the end. When will we take up in a practical and intelligent way the restoration of our forests?—*James J. Hill at the Governors' Conference.*

MASTER CAR BUILDERS' ASSOCIATION.

ABSTRACT OF COMMITTEE REPORTS.—(CONTINUED FROM PAGE 271.)

Ventilating and Heating of Coaches and Sleeping Cars.

Committee—S. G. Thomson, chairman; B. P. Flory, T. H. Goodnow.

The work as assigned to the committee on the ventilating and heating of coaches and sleeping cars was: "To investigate methods for the regulation of the temperature and the supply of fresh air to passenger cars, with special attention to sleeping cars, and to recommend plans which provide for the regulation of the heat and the air supply by the occupant of each berth."

The principles involved in this subject are so broad, the variations of the conditions so great, and the state of the art so undeveloped, that the committee considered it best to limit its investigation and suggestions to general lines, and not to include any more detail than was necessary to illustrate some of the important principles, and to describe a few of the best metliods in use.

Special effort was made to obtain information from the Pullman Company concerning its ventilating experience and plans for betterments, as well as to have one of its representatives present at a committee meeting; but the Pullman Company did not have anything to present. For this reason the conclusions and recommendations as given in this report, concerning the Pullman equipment, are not based on any definite information or data that have actually been obtained, but rather are formulated from the views of the various railroad officers as expressed in their communications and from the personal views of the committee.

The information which the committee was able to obtain failed to reveal any variety of thoroughly successful ventilating systems which have been extensively tried out, or new devices which are being developed; and the work as outlined seemed to resolve itself into a question of collecting information concerning the few older systems and devices that have been in use, and of developing arguments and ideas concerning new methods, such as any one might wish to propose.

About forty years or more ago, Professor W. Ripley Nichols, of the Massachusetts Institute of Technology, made some investigations of a system in use at that time known as the Winchell Ventilating System. This system was arranged so that air was admitted to the car at the end under the front hood, then allowed to distribute as it would through the car, and to pass out under the rear hood, without any attempt being made to warm it as it entered. Professor Nichols determined that 7,000 to 10,000 cubic feet of air per hour was furnished under favorable conditions. Later experiments with this system at Altoona indicated that 15,000 to 25,000 cubic feet of air per hour was furnished, uepending on conditions. It was also found that the movement of air in the car was hardly perceptible when the car was standing still, there being even less air movement with the large openings than is found in many of our more tightly closed modern coaches.

The next type of ventilating system was that found in the early type passenger coaches, known as the Spear Stove System. It consisted of hoods or intakes at diagonal corners of the car, which intakes were connected with the coal stove. The movement of the car forced the air down around the stove and into a box running the length of the car along each side above the floor. From this boxing or duct the warmed air was admitted into the car through various openings in the side of the duct. It then ascended through the body of the car and passed out through the deck sash. This system was a great improvement over any that had thus far been tried, but it was still subject to the following defects: When the car was not moving, the current of warm air was reversed and passed from the car out through the intake. Another trouble was, that the proportion of exits and intakes was not such as to give a balance of pressure between the inside and the outside of the car, and the exits were so much in excess of the intakes that cold air in the winter time would be drawn in around the windows and through every crevice. The trailing deck sash gave rise to various cross-currents, since it was often found that air would enter the car through the deck sash instead of going out, as it should. These cross-currents, in the upper deck interfered with the proper burning of the lamps, and did not change the air to any extent as low down in the body of the car as the breathing line. The deck sash also admitted cold draughts, cinders and smoke overhead, to such an extent as to be very annoying. The construction of the deck sash had not been brought up to the higher state of development in which we find it in use to-day on some of the most improved equipment.

The Spear Stove System was modified later by removing the stoves and by substituting for them steam radiator pipes extending the length of the car in the air duct, and by adding ventilators on the upper deck of the car roof. This was an improvement, in that it eliminated the stove and gave an exit for air, other than the deck sash. With some slight modifications, such as the adding of extra radiators at the ends of the car, just inside the doors, this was the type of ventilating system that immediately preceded the modern indirect systems now in use.

The deck sash system, which is now very generally used, was evolved from various former arrangements of deck sash, and its construction has been improved so as to eliminate many of the objectionable features of the former arrangements. The use of wire netting outside of the sash has largely eliminated dirt and cinder entering. This deck sash method of ventilation necessarily separates the heating and ventilating systems, and does not warm the air before it comes into the car. No special air intakes are provided, except the deck sash, and the change of air in the car is limited to the amount that will pass in and out through these openings. When the deck sash is thrown open in the winter time, it very quickly relieves an overheated car, as some of the cold entering air drops into the body of the car to take the place of the heated and vitiated air. This momentary dropping of cold air is effective in relieving a stuffy and overheated car, but continuous draughts created in this way are very objectionable to passengers in cold weather. In the summer time, this dropping of the cool currents is not so pronounced, and the movement of air is not sufficient for good ventilation. This system has been used in the Pullman cars for a long time, but it is now being modified by the application of a late type of the Garland ventilator to the deck sash. This ventilator has eliminated the objectionable down-draughts by creating a strong exhaust, and thus directing all the currents upward and outward through the roof.

The present standard ventilating arrangement of the Pennsylvania R. R. was started in its development more than ten years ago, and is the result of a number of years of study and experimental work. A large number of tests were made, resulting in modifications and changes, each change being followed by runs on the road, and by analyses of air taken from the cars under various conditions. The arrangement, as thus developed, has been gradually applied to cars, until it is now in service on more than one thousand coaches. The system admits the air through hoods located on diagonal corners of the car. The air passes down a vertical boxing to a horizontal duct under the floor, which duct runs the length of the car between the side and the adjacent intermediate sills. Then the air ascends through slots in the floor to a longitudinal boxing or duct containing steam pipes, extending along the sides of the car, above the floor and immediately over the air duct, thence through galvanized iron tubular pipes under each seat to the aisle, where it ascends and passes out through globe ventilators located over the lamps along the center line of the upper deck.

The system is designed to furnish one thousand cubic feet of fresh air per hour per person, while working normally on a moving train. This figure was based on there being 60 passengers to the car, which would require 60,000 cubic feet of air per car per hour, a complete change of air in the car fifteen times per hour, or once every four minutes. That this amount of air is furnished by the ventilating arrangement, has been proven by numerous tests which were made during its development. Samples of air were taken under various conditions from cars filled with workmen, while the train was running at speed with all the ventilators open; also, while the train was running with all the ventilators closed, as well as while it was standing still with all the ventilators open. The analyses were made by a test for carbonic acid in the air, and the calculations were made by determining the amount of fresh air that it would take to dilute the estimated amount of carbonic acid exhaled by the number of men in the car, so that the air in the car would equal in carbonic acid the amount that was actually found to exist in the samples taken. A representative test made in the winter time under normal conditions, showed by this method of calculation that 62,400 cubic feet of air per car per hour was furnished, while the train was running about 30 miles per hour with all the ventilators open; 27,000 to 37,000 cubic feet of air was furnished while running with all the ventilators closed, and about 23,000 cubic feet while the train was standing with the ventilators open.

The operation of the system is not entirely dependent on the movement of the car; since, when the car is standing still, the normal circulation of air is maintained by the rising heated cur-

by the Pullman Company, in that an air intake as well as an exhaust, is provided by a combination ventilator. This ventilator has been in operation above five years on the above railroad, where it has been developed in connection with the Automatic Ventilator Company. This latter company has patents controlling the use of this device.

This ventilator is arranged to be substituted for the regular deck sash; or, in cases where it is desired to have an opalescent or other decorative inside sash as a part of the interior finishing of the car, the ventilator can be arranged outside of the sash, and so constructed that the opening of the deck sash will open the ventilator. The device also can be arranged to extend through the car roof, and may be adapted to a car with any design of upper deck. The general arrangement of it is always the same, and consists of two openings or ducts extending into the car, each about 4 by 6 inches in size, with a deflector located between them and extending outwardly at right angles to the panel through which the ducts pass. The proper shutters, screens and other details are provided for controlling the device, and for the exclusion of dirt, cinders and rain. The end of the deflector is bent so as to scoop the air into the forward duct and to exhaust it from the rear duct. Some of the tests show that about 100 cubic feet of air per minute enters the intake side of one ventilator and 116 cubic feet is drawn out of the exhaust side, while running at speed. Tests are now being made to determine the extent that the air is changed in the lower part of the car. A considerable difference in temperature between the outgoing and the incoming air, as has been shown by the numerous tests already made, would seem to indicate that an effective circulation is maintained down through the body of the car. A panel ventilator of this kind has been constructed to take the place of a screen in the lower berth of a sleeping car, the thought being that the occupant could manipulate it to admit air to the berth, or to exhaust it from the berth, as he might desire.

The report has thus far included a description of three distinct systems or principles of car ventilation. The first one is a balanced intake and exhaust system in which the air is warmed before it enters, and must pass through the body of the car before it is exhausted. The second is either a combination admission and exhaust deck-sash arrangement, or, in its later developments, is strictly an exhaust system without any special intakes, in which case the air enters wherever it can and is drawn to the upper deck from all parts of the car. The third system is a combination admission and exhaust arrangement located in the upper deck, with a special ventilator arranged to force and to regulate the air circulation. The first system involves the indirect method of heating, while in the other two arrangements the air is heated by radiators after it is in the car. All other arrangement in use are modifications or combinations of these principles, except the forced-draught or fan system.

The principal argument in favor of the direct method of heating is that fresh, cold air directly from the outside is more invigorating than it is after the life is taken out of it by passing it over heating pipes. Another argument is that passengers desire to see the deck sash open, and that this in itself makes them think they are getting good ventilation. While there may be some weight to the latter argument, they both seem to be misleading in not making a distinction between the heating and the ventilating of a car. Heating does not mean ventilation, nor does ventilation mean heating; since a stifling hot car may be well ventilated, and since a car kept at exactly the proper temperature may not have any ventilation at all. Most of the complaints made by the traveling public are the results of an improper heating of the cars rather than an insufficient change of air in them; not that the ventilation is less at fault than the heating of the car, but because differences in temperature are much more easily and quickly felt than is a lack of ventilation. A passenger can stand a little cold air for a few minutes, as when relieving an overheated car; but when a considerable amount of air is required continuously for any length of time in order to provide the necessary change of air for good ventilation, the committee believes that it must be warmed before it is introduced into the car by some kind of an indirect heating system.

It is the opinion of the committee that, for a given amount of air movement through a car, this air can be heated more satisfactorily and with less steam by the indirect method, than it can by the direct method, on account of a better circulation being maintained around the steam pipes by the indirect system; therefore, it would recommend that the indirect method of heating be used for all new equipment, and for such present equipment as it is practicable to change from the direct to the indirect system. For such coach equipment as it is not expedient to change to the indirect system of ventilation, the committee suggests that extended experiments be made with combination admission and exhaust ventilators located in the upper deck.

Many authorities on ventilation claim that the down-draught system is the only one that should be used for buildings, while others state that the warm air should be admitted near the floor through as many openings as possible, and taken out at the ceiling. An argument in favor of the down-draught system is: that carbonic acid (CO_2), being heavier than air, falls as it is exhaled; also that the breath is exhaled in a downward direction, which assists the falling tendency, and therefore the carbonic acid should be taken out at or near the floor. Another argument is, that the only way to prevent perceptible air currents, is to introduce warm air overhead and allow it to spread uniformly under the ceiling and then to diffuse equally all through the room, rather than to introduce it at the floor and allow it to rise to the breathing line in currents which carry with them dust and microbes from the floor. It is hardly probable that the carbonic acid as exhaled is sufficiently heavy to cause it to fall, since it is usually at 10 to 15 degrees higher temperature than the surrounding air, nor would the addition of about 4 parts of carbonic acid to 10,000 parts of air be likely to counteract the rising tendency of the comparatively large body of air with which it was mixed. However, while this is entirely theoretical, it is the possibilities of actual application that govern, and on this account it is doubtful if the down-draught system could be applied satisfactorily to any type of passenger car. The committee does not recommend the down-draught system of ventilation for any kind of passenger equipment.

It is generally conceded that a forced-draught system is not necessary for the usual equipment in regular service. With reference to special service equipment, such as dining cars, private cars, and certain sleeping cars, the committee believes that a proper forced draught or blower system is, in some cases, necessary and very desirable, as an addition to the regular methods of ventilating these cars. A sleeping car that stands at a terminal in the summer time from 9 P. M. until after midnight to receive passengers, should certainly have some auxiliary means for forcing ventilation, which could be used until the car leaves on its trip. It should be possible to keep a few cars in this kind of service, and to equip them with a blower or an exhaust fan system that could be used in connection with the ducts of the regular indirect heating and ventilating system of the car. These ducts should lead to each lower berth, and the system might be arranged, either to blow fresh air into the berth or to exhaust the vitiated air from it. The committee does not believe that the fan or blower system would be warranted for all regular equipment, since it would be too expensive to install, and since it could not be maintained in good condition by the ordinary attention that it would receive from the porters and train crews.

Some claims are made that the dropping window would allow cool, fresh air to be admitted to the car over the heads of the passengers without striking them directly, and that such an arrangement would have somewhat the same good effect as the dropping of a window in a house to allow vitiated or overheated air to pass out. The committee does not believe that this arrangement would be satisfactory for a car window, as, at best, it would be useful only in mild weather, and would be more objectionable than the open deck sash in cold weather. The incoming cold draught might not strike the person sitting next to the window, but, as it would descend in the car, it would be very objectionable to the passengers sitting farther back. A constant opening at the upper part of the window would be too low to give much relief to an overheated car, and it would create undesirable draughts and cross-currents around the heads of the passengers in cold weather. In warm weather the passengers wish to have the window entirely open and the sash out of the line of vision; so that, in this respect, it does not make any difference whether the sash is raised or lowered.

Some claims are made that the present screen arrangement in the lower berth is good enough, since in any event the porter would usually be asked to make the necessary adjustments before the passenger would retire. This may be true, but the screen arrangement does not allow the occupant to close the window during the night if the berth becomes too cold, or to have a screen inserted if the berth becomes too warm. An easily operated window would place the ventilation of each berth in the control of the occupant.

Various arrangements for window ventilation might be applied. A rolling screen might be attached to the window so that it would close and open with the window. Another arrangement would be to place the regular screen under one sash, and to have the other sash balanced and the fixtures so arranged that it could be opened or closed to whatever extent the occupant of the berth might desire. Another means of ventilation, and one which would not require the use of a balanced sash, would be to use, instead of the usual screen, a ventilating panel of the "Automatic Ventilator" type, having screened openings which could be used to admit or to exhaust air, and which could be opened or closed at the discretion of the occupant of the berth. A proper manipulation of such a device should give better results than do the plain screen openings as now used. Very fine screens would necessarily have to be used on the intake side of such a ventilating panel, on account of the extra movement of air into the berth, which would tend to bring in with it an additional amount of cinders and dust. Still another method for ventilating the lower berth would be to extend a short duct through the walls of the car from each lower berth to a venti-

"A," and this space is connected by means of a small copper pipe to a recording gauge of the Bourdon tube type. The attachment to the coupler and car is shown on Sheet 18 (not reproduced). The desired side clearance can be adjusted by placing blocks inside the yoke connecting the registering device to the coupler. As the space containing the liquid is very small the travel of the piston and consequent lateral play of the coupler beyond the desired clearance will be practically negligible. The calibrations will be made from an initial pressure to avoid any errors due to lost motion. The question of purchase of this dynamometer at the expense of the Association has been referred to the executive committee, and if approved, the committee hopes to furnish some definite data on this subject next year.

ATTACHMENT OF YOKE TO BUTT.

There is some dissatisfaction with the present method of attaching coupler yokes to the butts, but to date no other method has been presented which, in the judgment of the committee, would be an improvement. It has been suggested that additional lugs be cast on the coupler shank to form a pocket for the yoke gibs between these lugs and the coupler butt. The object of the extra lugs is to force the yoke gibs to fit against the coupler butt and thereby avoid placing the rivets in shear. Your committee assumes that it is expected to deal with couplers without machining and to use yokes as they are forged, which necessarily means some allowance from the drawing sizes. The pocket formed on the coupler shank, unless machined, will not be accurate, which also holds true in the case of the gibs on the coupler yoke. Even with good machining it is difficult to obtain fits of one yoke gib in the pocket, and this difficulty is increased as the two gibs of the yoke must be fitted at the same time. If any motion is allowed, to that extent the rivets are subject to shear, and practical application with any workmanship that is likely to be secured within reasonable cost will result in a certain amount of clearance between the yoke and lugs, however placed. and the stress will be placed upon the rivets until such time as they are worn or sheared enough to allow all parts to come into bearing.

Another suggestion is the use of four short rivets instead of two long rivets, the idea being that the short rivets can be better heated so as to completely fill the hole when driven. Experiments have been made along this line, but no decided advantage to offset the additional cost was found. The present standard providing for 1¾-inch bearing top and bottom for the rivets is a decided improvement over the old design of butts, and the main difficulty at the present time is the relatively poor fit of the yoke to butt and the membering of the rivet holes. If more care is exercised in this fitting it will greatly increase the efficiency of the attachment. To further this end the committee is designing gauges for the relative location of the rivet holes to the gib bearing surface on the butt and the similar spacing on the yoke. It is believed, however, that the rivet holes in the butts should be drilled or broached to insure better fitting of rivets, and the committee, therefore, makes this recommendation.

Standard Marking of Freight Equipment Cars.

Committee—R. L. Kleine, chairman; T. H. Russum, W. O. Thompson, C. B. Young, J. F. Dunn.

At the last convention the committee on standards and recommended practice presented a communication from Mr. W. F. Allen, Secretary of American Railway Association, relative to recommendations from Mr. Arthur Hale, chairman of the American Railway Clearing House, in regard to marking cars with standard initials and the suggestion that the initials and numbers should be painted in some uniform place on each car, and not too high. It was also stated that Mr. Hale had taken up the subject of standard initials for marking freight cars with the Association of Transportation and Car Accounting Officers.

The object of this suggestion is to facilitate car checking, particularly at night, the intention being to recommend a uniform location and height for the initials and numbers of cars, and with this understanding the suggestion was approved by the committee on standards, which offered the following additional paragraphs to the section on stenciling cars:

"The initials and numbers of all cars having a superstructure, which will permit, shall be placed about midway between the door and corner post on the left-hand side of the car, and be arranged at a height of 4 feet 9 inches from the rail to the underside of the bottom row.

"It is further recommended that the name of the railroad should also be placed on this end of the car over the initials and number, and that the space at the right-hand end of the side of the car be reserved for the marking showing capacity, dimensions, weight, etc."

In view of the various standards of marking in use by the railroads, many of which possess points of merit, and the fact that the construction of the cars regulates to some extent the location of the marking, the committee is of the opinion that the location of the marking should not be confined within narrow limits, but a recommended practice governing it should allow sufficient latitude to meet conditions and at the same time confine the location so that it will facilitate the work of car checkers, conductors, scale men, inspectors, and others, whose duty it is to take information from markings on cars.

Although the work assigned to the committee was to consider the location of the initials and numbers of cars, it was found that the locations of other markings were so closely allied to those of the initials and number that they have also been included, subject to approval.

With this end in view, the committee submits the following recommendations for consideration:

MARKING ON FREIGHT EQUIPMENT CARS.

1. Freight equipment cars that have a superstructure which will permit should be stenciled with markings on sides of car, in the following order:

Lettering (Initials or Name of Road),
Number,
Capacity,
Light Weight.

This marking is to be located as nearly over the truck as the lettering will permit, preferably to the left of center line of side of car. On box and other house cars where doors slide to the left, the above marking may be placed to the right of center line of side of car. On any other cars where the construction makes it necessary, this marking may be placed either to the right of center line of side of car, or in the center of side of car. The distance from the center line of coupler to the bottom of car number to be normally 2 feet 4½ inches, with a minimum dimension of 1 foot 10½ inches, and a maximum of 2 feet 10½ inches. The spacing of the remaining marking to be as shown on diagram. (Not reproduced.)

This location will place all the information necessary for the ordinary handling of cars in yards, freight sheds and over scales, in such a position that it can be easily read, both day and night, from the ground, platform, or scale, by conductors, scale men, car checkers, inspectors, agents and any other men whose duty it is to take information from markings on cars.

By placing the light weight below the capacity, it will facilitate restenciling this information when necessary at times of reweighing. Space should be left between the light weight marking and the bottom of car side to allow for restenciling at time of reweighing, as it is impracticable to stencil over the old marks without giving time for body color paint to dry.

In order that the markings may be most effective, the committee suggests the use of 9-inch letters for the name or initials, 7-inch figures for the number, 3-inch letters and numbers for the capacity and 4-inch letters and numbers for the light weight as preferable sizes for this lettering and numbering, although the alternate sizes now given in recommended practice may be used if desired.

2. The ends to show the initials or name of road, car number and light weight, in the upper half of end of car. On box or other house cars having end doors, this lettering should be so located that it will not be obscured when doors are open.

The upper half of end is preferable, as the lower half is more frequently covered by dirt and grease thrown upward by the wheels of the preceding car, which would obscure the marking if placed on this half of car end, and in case it is necessary for a conductor to take any numbers while train is in motion, they can be much more readily seen from the top of car.

The initials, number and light weight on end of car are of paramount importance to scale men, as it enables them to compare the initials and number with the manifest and enter the light weight before the car reaches the scale platform, besides assisting the weigher to set the scales.

3. Flat and low sided gondola cars should show the lettering (initials or name of road), number, capacity and light weight on the side of car in the best available location offered by the construction of the car. Suggestions as to the arrangement of this lettering are shown in the diagrams. (Not reproduced.) When possible, the sizes of lettering and figures should correspond with those used on other freight equipment cars. The end marking on flat cars may be omitted.

It is self-evident that no specific recommendations in regard to location of lettering on flat and low-sided gondola cars can be made, due to the limited available space upon which to place the lettering, in addition to the variation in construction, and it was thought desirable to only specify that the necessary markings should be placed upon the cars leaving the location optional, so that it can be best suited to the construction.

4. Side and end doors should be stenciled with the initials or name of road either on the outside or inside of door. If placed on the inside the stenciling should be so located that it will not be defaced by the sliding of the door.

This stenciling is considered essential to enable railroads to determine the ownership of doors which are lost off.

If the above recommendations meet with approval the present recommended practice relating to the "marking of fast freight line cars" should be dropped, as the proposed arrangement covers all cars.

The committee on standard and recommended practice re-

There should be at least four bottom guides, located so that not less than two guides will engage the door in any position. Each guide should be secured to the sill of the car by at least two ½-inch bolts. The bolts for the guide at rear corner of door in closed position should have the nuts riveted over or bolts locked in other suitable manner.

The door hasp staple should be secured with two ⅜-inch carriage bolts, with the nuts inside and a washer under the nuts. The frame should be counterbored for the thickness of the nuts. The door hasp fastener should be secured with not less than two ⅜-inch bolts, with the nuts inside, and it is recommended that the fastener have a flange that will lip over the back of the wooden door stop. The door hasp fastener is a specialty which is usually purchased from manufacturers, therefore no drawing has been made.

The use of door hangers of patented designs has become almost universal, therefore it does not seem desirable to attempt to show a design for them. Each door hanger should be secured with not less than three bolts at least ⅜-inch diameter with nuts outside.

The track for the door hangers should be of some standard structural steel shape at least 3-16 inch thick, which is readily procurable on the market. The track should serve the double purpose of a runway for the hangers and a weather proof and spark proof door hood. The track should also be arranged so that the door cannot drop off if the hangers are broken.

End doors are not generally used on box cars, therefore the end door and fixtures for them have been omitted.

Protective Coatings for Steel Cars.

Committee—G. E. Carson, chairman; T. Rumney, S. A. Cromwell.

The committee at this time has some few cars under test, as follows:

One car covered with a coating of crude petroleum oil;

One car painted with special black paint and covered with a coating of good fish oil;

One car painted with special black paint and covered with a coating of locomotive cylinder oil;

One car painted with common paint and covered with equal parts of raw linseed oil and pure glycerin;

One car painted wth common paint and covered with Cleanola;

One car painted with common paint and covered with well-rubbed-in commercial tallow.

All of the above cars were sprayed on the inside with crude petroleum oil.

Following are the recommendations as far as the committee has gone:

Suitable buildings should be provided for the painting of cars, so that the painting of the equipment would not necessarily be confined to certain seasons of the year.

In the preparation of the assembled parts of new cars, they should not be exposed to the weather or permitted to rust before their assemblage. In all cases where metal is placed against metal, either riveted or bolted, it should be free from flash or rust and covered with one or two coats of red lead, and the mixture be heavy enough to exclude moisture. But this precaution will avail little unless extra care is taken that all the steel parts fit evenly.

After cars are ready for the first coating, it is necessary that all flash and rust be removed. This should be done under rigid inspection. Unless the flash is removed it will invariably begin to fall off inside of a year and continue as long as any remains, regardless of the number of coats of paint applied. It is recommended that all flash and rust be removed by sand blast, where possible. Dry cleaning (which is not as satisfactory) is also recommended by using steel scratch brushes, sandstone, or any tools which will answer the purpose, being particular to remove all the dust with suitable brushes or dusters. After following either of these cleanings, the application of three coats of paint at twenty-four-hour intervals is suggested.

In the preparation of cars for repainting, cleaning by sand blast is recommended, but if this cannot be done, then use the dry-cleaning process, as previously mentioned. After the dry cleaning, two coats of standard paint should be applied at twenty-four-hour intervals.

After taking all these precautions to protect the outside of the car, under ordinary conditions it is necessary to repaint at the expiration of three years, and where conditions are unfavorable to the equipment it will be necessary to repaint oftener.

The committee cannot be too emphatic as to the necessity of taking the proper care of the exterior, and regrets not being able to give the interior equal care.

The best of paint should be used in order to prevent rust after painting, and by using paint which has the greatest wearing elasticity, the less liability there is for the penetration of moisture. Adhesion is just as important, and to have perfect adhesion, the paint should dry from the inside out, the same as good varnish.

Elasticity must also be considered, for where adhesion is perfect and no elasticity in the materials, we cannot hope for good results. For the reason that expansion and contraction of the plates must be provided for, the use of linseed oil or its equivalent is preferred.

The painting of the inside of steel cars has been thought by some to be beneficial, but the committee can see no lasting benefits in this, and do not recommend it, but is of the opinion that coating the interior of the cars about once every six months with black oil would act as a preservative.

Further than this the committee is not able to offer any recommendations, and asks to be continued for another year in order to determine the results of the tests which are being made.

Triple Valve Tests.

Committee—A. J. Cota, chairman; R. K. Reading, E. W. Pratt, F. H. Scheffer, D. C. Ross.

The committee reported that the new 100-car, 10-inch, brake-cylinder testing rack has been built and shipped to Purdue University at Lafayette, Indiana, and that the material is now stored awaiting the completion of a room that is being especially built for housing the test rack. This building will be completed about June 20.

Journals on Standard Axles.

The topical discussion on the question: "Should journals of standard axles when fillets are partially worn, be made longer in order to get in a full size fillet? If so, what should be the limit of the length of journals?" was opened by W. E. Fowler (Can. Pac.) as follows:

"There are very few iron axles put under modern freight cars. The axle of to-day is that made of open hearth steel, a material which does not give good service in carrying heavy loads, or in sustaining severe shocks if its outline be disposed into sharp corners or angles, and the designers of the M. C. B. standard axles accordingly have provided, that, where there is a step or change of diameter, there should be a fillet or curved graduated connection between the larger and smaller diameters, since if a sharp corner or right angle be allowed, a fracture is invited at that point, and a great loss of property will probably ensue.

"The lengthening of journals of axles in order to replace worn fillets is a practice which is more or less followed on all railroads, but so far as my knowledge extends, there are no generally observed limits to this extension of length. In my opinion an axle with the journal fillet entirely worn out should, when withdrawn for changing wheels, be scraped. The reformation of the entire fillet with the consequent lengthening of the journal, is an unsafe practice, as when the fillet is quite worn out there is, in all probability, an incipient crack where the fillet formerly was, and it is only inviting trouble to return such axles to service.

"Considering the disastrous results that follow a broken journal, I think "an ounce of prevention is worth a pound of cure" in this as in many other cases, and the prevention consists in scrapping all axles with worn out fillets.

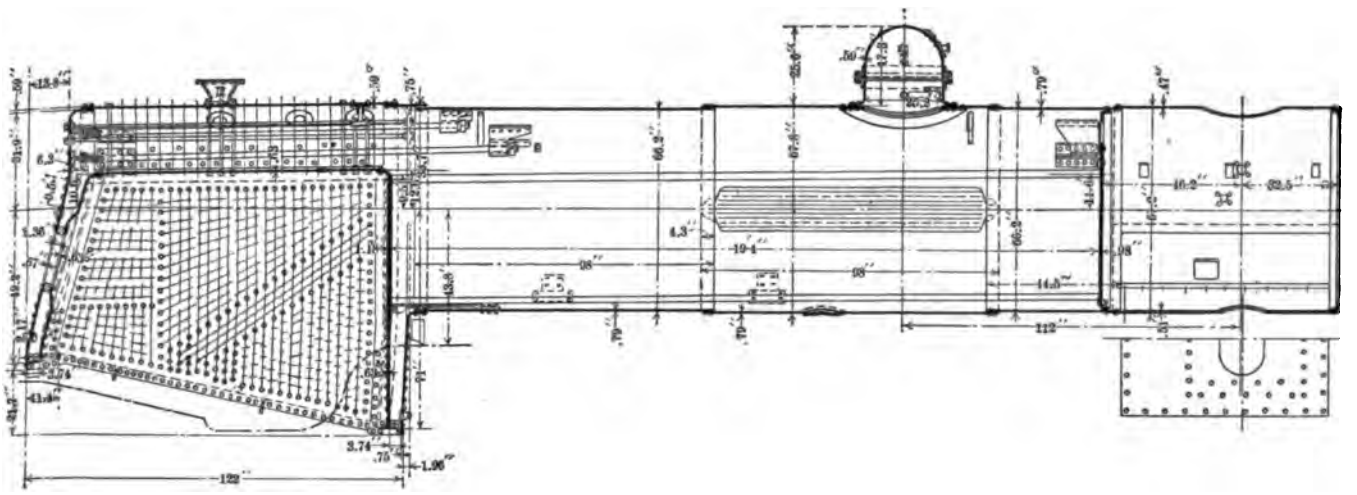
"There are, however, many axles drawn from service on account of wheel failures that have fillets partially worn, and which may in the opinion of many be made fit for long further service by putting them in the lathe and lengthening back the dust guard shoulder and so renew the fillet, so essential to the load carrying ability of the journal.

"I think it will be agreed generally that excessive lateral movement of the journal bearing on the journal (which, of course, means also movement of the superimposed load) is not desirable, in fact, that it is injurious to wheels, axle, and truck, car body and track, and in view of the heavy loads now carried, the speed attained and the consequent stresses on the wheel flange, we should make our wear limits less and our inspection more rigid, to preserve the same factor of safety with the heavy capacity car and the high speed that we formerly had with the light car and low speed.

"We have limits of diameter for journals, wheel seats and axle centers, we have limits for thickness of collars, and we should have limits for length of standard journals, for the reasons enumerated, as also to keep within reasonable limits the lateral movement of journal bearings (and consequently the truck frame) on the journals.

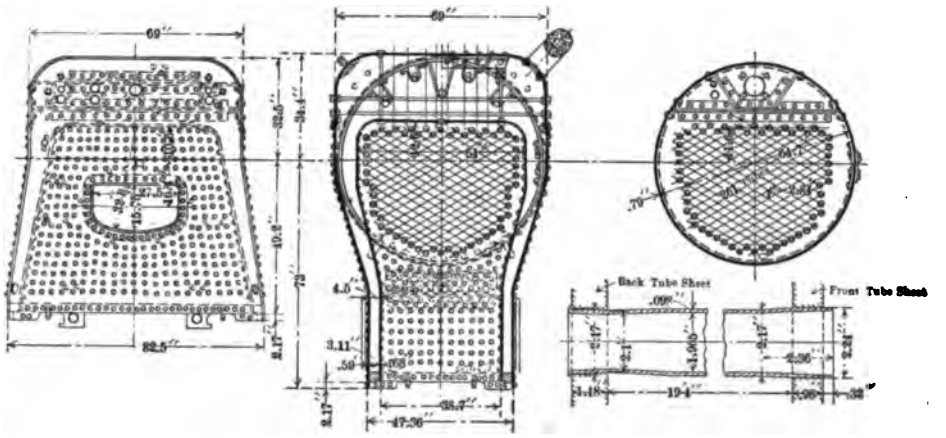
"In view of my opinion that only partially worn fillets should be reformed by lengthening the journal, I think that a length limit of 7½ inches should be set for 7-inch journals, 8½ inches for 8-inch journals, and 9½ inches for 9-inch journals, and 10½ inches for 10-inch journals."

Mr. Hennessey agreed with Mr. Fowler and on a motion by Mr. Forsyth the subject was referred to the committee on standards.



cast steel center frame. The truck is brought back to its central position after leaving a curve by means of two transverse coil springs, one on either side of the center plate.

The tender tank is of the water bottom type and has a water capacity of 5,300 gallons. It is provided with three gauge cocks on the left side to show the level of the water in the tank. The tender frame consists of two steel plate side frames, placed outside of the wheels and strongly braced together. The tender is carried on six wheels and the weight is transmitted to the journal boxes through semi-elliptic springs over the top of each box, the two rear pairs of wheels being equalized together.



BOILER—DE GLEHN COMPOUND LOCOMOTIVE.

The general dimensions, weights and ratios are as follows:

GENERAL DATA.

Gauge	4 ft. 9 in.
Service	Passenger
Fuel	Coal
Tractive effort	24,940 lbs.
Weight in working order	195,000 lbs.
Weight on drivers	122,000 lbs.
Weight of engine and tender in working order	294,800 lbs.
Wheel base, driving	12 ft. 9.54 in.
Wheel base, total	34 ft. 5.4 in.
Wheel base, engine and tender	58 ft. 5.2 in.

RATIOS.

Weight on drivers ÷ tractive effort	4.2
Total weight ÷ tractive effort	7.8
Tractive effort × diam. drivers ÷ heating surface	597.0
Total heating surface ÷ grate area	66.5
Firebox heating surface ÷ total heating surface, per cent	6.1
Weight on drivers ÷ total heating surface	40.2
Total weight ÷ total heating surface	61.1
Volume equiv. simple cylinders, cu. ft.	8.0
Total heating surface ÷ vol. cylinders	380.0
Grate area ÷ vol. cylinders	5.7

CYLINDERS.

Kind	DeGlehn Comp.
Diameter and stroke	15.35 and 25.2 × 25.6 in.

VALVES.

Kind	H. P.-Piston, L. P.-Slide
Greatest travel	H. P.-5.25 in., L. P.-5.7 in.
Outside lap	H. P.-1.06, L. P.-1.06 in.
Inside lap	H. P.-.118, L. P.-.197 in.

WHEELS.

Driving, diameter over tires	72.8 in.
Driving journals, diameter and length	8.65 × 9.45 in.
Engine truck wheels, diameter	37.8 in.
Engine truck, journals	5.9 × 9.85 in.
Trailing truck wheels, diameter	45.2 in.
Trailing truck, journals	7.1 × 11.8 in.

BOILER.

Style	Belpaire
Working pressure	227.6 lbs.
Outside diameter of first ring	66.2 in.
Firebox, length	112 in.
Firebox, width	F.-38.8, B.-74 in.
Firebox plates, thickness	.63 in.
Firebox, water space	F.-3.74, S.-3.1, B.-3.66 in.
Tubes, number and outside diameter	261—2.17 in.
Tubes, length	19 ft. 6 in.
Heating surface, tubes	2,863.5 sq. ft.
Heating surface, firebox	184.7 sq. ft.
Heating surface, total	3,048.2 sq. ft.
Grate area	45.7 sq. ft.
Smokestack, diameter	19.7 in.
Smokestack, height above rail	171 in.
Center of boiler above rail	111 in.

TENDER.

Tank	Water Bottom
Frame	Steel
Wheels, diameter	48.8 in.
Journals, diameter and length	5.5 × 9.85 in.
Water capacity	5,300 gals.

LONGITUDINAL VS. TRANSVERSE SHOPS.

After a thorough experience with both types, I have come to prefer the longitudinal shop for any location where the surroundings will permit its use. My principal reasons for this preference are as follows:

(1) The transverse requires between twenty-five and thirty per cent. more erecting floor area per locomotive under repairs, and about fifteen per cent. more machine shop area than the longitudinal shop. These figures are based on, and confirmed by, a comparison of ten well-known shops; five of each type.

(2) The longitudinal shop has greater flexibility as the number of engines under repairs can be varied according to their size and the spacing required, while in a transverse shop, the pits, drop tables or cranes, etc., cannot be lengthened out to fit larger power at a reasonable cost. For this reason many transverse shops have been entirely outgrown by the large modern power, and, if the articulated type of locomotives come into general use, most of the modern transverse shops will very soon be outgrown in the same manner. This is not true to the same extent of old longitudinal shops, nor is it at all probable with any of the recent shops of this type.

(3) The cost per square foot of area averages somewhat less for longitudinal than for transverse shops on account of the design of the building. The transverse shop generally requires large double doors for every pit, and the cost of the pits themselves is greater, besides some other less expensive features in favor of the longitudinal shops.

(4) Advocates of both types of shop claim that their preferred

a new development, the single unit motor car can be built to-day for very much less money than a small locomotive and coach. On a cost per pound basis, the motor car has very much in its favor. An objection is made to the necessity of carrying an extra unit to maintain service. There is probably no class of mechanism in the country to-day requiring more extra units than the steam locomotive. Traction lines figure on an extra unit for every four or five cars.

The objections to "a small, highly specialized locomotive, preferably of the 0-4-0 type, attached to a combination coach," are a higher cost of operation; higher first cost of equipment; necessity of say four men in place of two for the operation; and serious objection to the smoke and cinders from any steam locomotive, especially in interurban service, where so many stops are made. This last objection is met with in the case of a steam motor car burning coal; but, with the gasoline car or gasoline electric car, this very objectionable feature is done away with—making travel a pleasure rather than an irksome task.

C. B. SMITH, Asst. Mech. Engr.
Union Pacific Railroad Co., Omaha, Neb.

FUEL ECOMOMY.

An interesting and valuable report on the question of smoke prevention and fuel economy was presented at the recent meeting of The Traveling Engineers' Association. The report was based largely on the replies to a series of questions which were submitted to the members and the following is an abstract of the most important parts of it.

A synopsis of the replies received, boiled down, results in the following conclusions: That fuel economy can only be effected through education; but that this education must not be confined to simply teaching the firemen how to fire or the engineer how to work his engine economically, but must extend from the bottom to the top, that is, from the man at the mines to the highest officer of the road, so that all will know and realize the importance of the subject and by their help and co-operation assist to bring about the desired results.

The efforts of the traveling engineer are confined principally to the men in the cab, and while very effective so far as they go, do not by any means accomplish all that could be done, were he granted full, absolute and extensive support. While granting that the traveling engineer is given a certain amount of support from the upper quarters, yet candor compels us to say that this support, except in a few notable instances, is of but an intermittent and perfunctory nature, and therefore as a whole not lasting and of little actual value. This, however, is not through any spirit of laxity or indifference on the part of the higher officials, but is brought about by conditions, and the fact that the average official on the American railroads is saddled with so many duties or has such an extensive territory that it becomes a hard matter to give each specific duty the attention that it deserves. With the mechanical man fuel economy is subordinated to maintenance of equipment and with the transportation man it is ranked by moving traffic, and, consequently, between the two the traveling engineer often fails to accomplish his ends simply for lack of proper support. Fuel economy and the results that can be obtained are of sufficient moment to warrant any railroad in putting on a special man to look after this one feature alone.

Do firemen study? The replies would indicate that firemen as a rule do not study to advantage. The free literature distributed by the various railroad companies on the subject of fuel economy is appreciated, but the men are more inclined to absorb the information through oral instructions and practical demonstrations. This, however, must not be taken as an argument against written or printed instructions. It simply proves the necessity of education along that line. The average fireman does not at first realize that he is simply an apprentice engineer and that when he reaches that position more will be required of him than simply 200 pounds of steam, and therefore does not care to puzzle cranium with the problems of combustion, but takes his ledge in the easiest form and less troublesome doses.

It has been noticed, however, that where firemen have through study mastered the principles of combustion they usually stand at the head of the list of firemen, and likewise after promotion to engineers they can do their work easier and better than their less educated brothers. The habit of applying brains to their work, formed when firing, remains to their after-advantage as engineers. As the future fireman will use his head as much as his back, we urge that all study be encouraged and to aid him to master what to many is a difficult lesson, that teachers or instructors or demonstrators (whatever you may call them) be employed to help the willing firemen over the rough places. The unwilling man has no place on an engine.

Assistant road foremen. We most emphatically advocate the employment of competent instructors, but would not call them traveling firemen, but assistant traveling engineers or assistant road foremen. They should have authority over the engineer as well as over the fireman, as without this authority, unless possessed of infinite tact, they might do more harm than good.

The assistant traveling engineer should be recruited from the ranks of engineers and should be a young, active and energetic man, one who can take the scoop when necessary and demonstrate to the fireman the correct way to handle it and get results —namely, the maximum amount of steam from the minimum amount of coal. In addition to being young and active and a first-class fireman, he should also be a first-class engineer, one who can, if necessary, demonstrate to the man on the right side of the engine how he can handle the engine to better advantage and, by so doing, help himself, the fireman and the company. This man would naturally fall in line for the position of traveling engineer when the latter is promoted. He should be subordinate to the traveling engineer and should either work directly under or else in harmony with him.

Inspection of ash-pans, etc. Most roads require this and all intelligent firemen naturally do it. A few trips with the air openings stopped up soon convinces the fireman of the advantage of keeping them open, and the lesson once learned is not soon forgotten.

Instruction to fireman to keep the door closed, etc. This is another lesson that is soon taught by a little experience, but it is always advisable to teach it direct, instead of letting the fireman find it out for himself, as the opening of the door and leaving it wide open while the engine is forced to the limit in lifting the train to speed, is apt to cause other damage: leaky flues, etc.

When should grates be shaken? This depends largely on local conditions, the nature of the coal, etc.; all are agreed, however, on the manner in which the grates should be shaken, namely by short, quick jerks, and not a slow, rocking motion. All are also practically unanimous that as a rule it is much better to shake the grates when the engine is drifting or working light than when being worked hard.

Comparison of heating value of coal. This is a refinement in comparison to men and engine efficiency that is practiced by but few roads. We recognize the fact that it is not always practical on all roads and, except for a basis of comparison, is unnecessary. We believe, however, that comparison should not be made between two different divisions, unless all conditions are exactly similar, not forgetting density of traffic.

The comparison should only be made between similar engines in the same class of service on the same divisions, but even that comparison cannot simply be made between passenger and freight, work and yard engines, on a ten-mile basis, with fairness, where regular engines are assigned to and kept, through and local passenger service, fast, slow and local freight, etc., as in that case, to be absolutely fair, comparison should be on a ten-mile-per-hour basis. Time is the one important consideration that is often lost sight of in making any comparison.

Instruction of firemen on front end appliances, etc. Too much information on any part of the locomotive cannot be given to the fireman or, for that matter, to any one else whose duties throw him in contact with engine service. Where it may not be practical to move a draft sheet up or down in order to give the fire-

plant at the Louisiana Purchase Exposition, St. Louis, Mo. For three years the Government experts conducted a series of tests on many samples of coal from mines all over the country. Briefly, the apparatus included a non-condensing Corliss engine steam plant with a water tube boiler and a pressure type producer with a three-cylinder vertical gas engine.

From the summary of results obtained from a long series of tests, the fuel consumption in the pressure type producer plant varied from 1.18 to 3.47 pounds per brake horse power per hour, the average being approximately 1¾ pounds. The average with the Corliss steam plant was found to be approximately 4½ pounds, using similar fuels. With lignite, the consumption in the pressure producer plant was from 1.95 to 3.47 pounds, the average of five samples actually figuring 2.60 pounds. With the Corliss steam plant using lignite, the average consumption of "coal as fired" (not "dry coal") was approximately 7 pounds.

While most of the above tests were on bituminous coals, which cannot be used advantageously in a suction producer, yet the consumption of anthracite in the latter is usually less than as stated for bituminous coal in the "pressure" type producer, probably due to the fact that there is less resistance to the flow of gas in the suction type. For example, tests on lignite in a suction producer commonly show a consumption of 2 to 2¼ pounds, whereas from the five lignite tests at St. Louis the average is 2.60 pounds in a pressure producer plant.

ing, and the many plants which are in continuous operation, some of them twenty and even twenty-four hours a day, indicate that they are thoroughly reliable and will stand hard, every-day usage. Boiler insurance is unnecessary with producer plants and the troubles and dangers encountered with steam boilers are entirely avoided. The complete gas engine and suction producer plant is almost entirely automatic in operation, very little attention being required. Ordinarily the operator only needs to spend ten to fifteen minutes about every two hours to dump a few buckets of coal into the producer and give general attention to the plant. He can spend part of his time in other useful work and an extra man as fireman is not required, even with plants from 400 to 500 horse power.

Hundreds of thousands of dollars which are now spent annually in building smokestacks can be saved; and what is of greater importance, the smoke nuisance can be entirely abated.

Where the suction gas producer plant uses 1¼ or 1½ pounds of coal, the steam plant commonly requires 4 to 6 pounds, or more. Moreover, with the producer plant there are fewer ashes to be handled and disposed of.

The producer will hold fire all night or even for several days, and the proper quality of gas can be generated after fifteen or twenty minutes blowing to revive the fire. The engine can easily be started on compressed air.

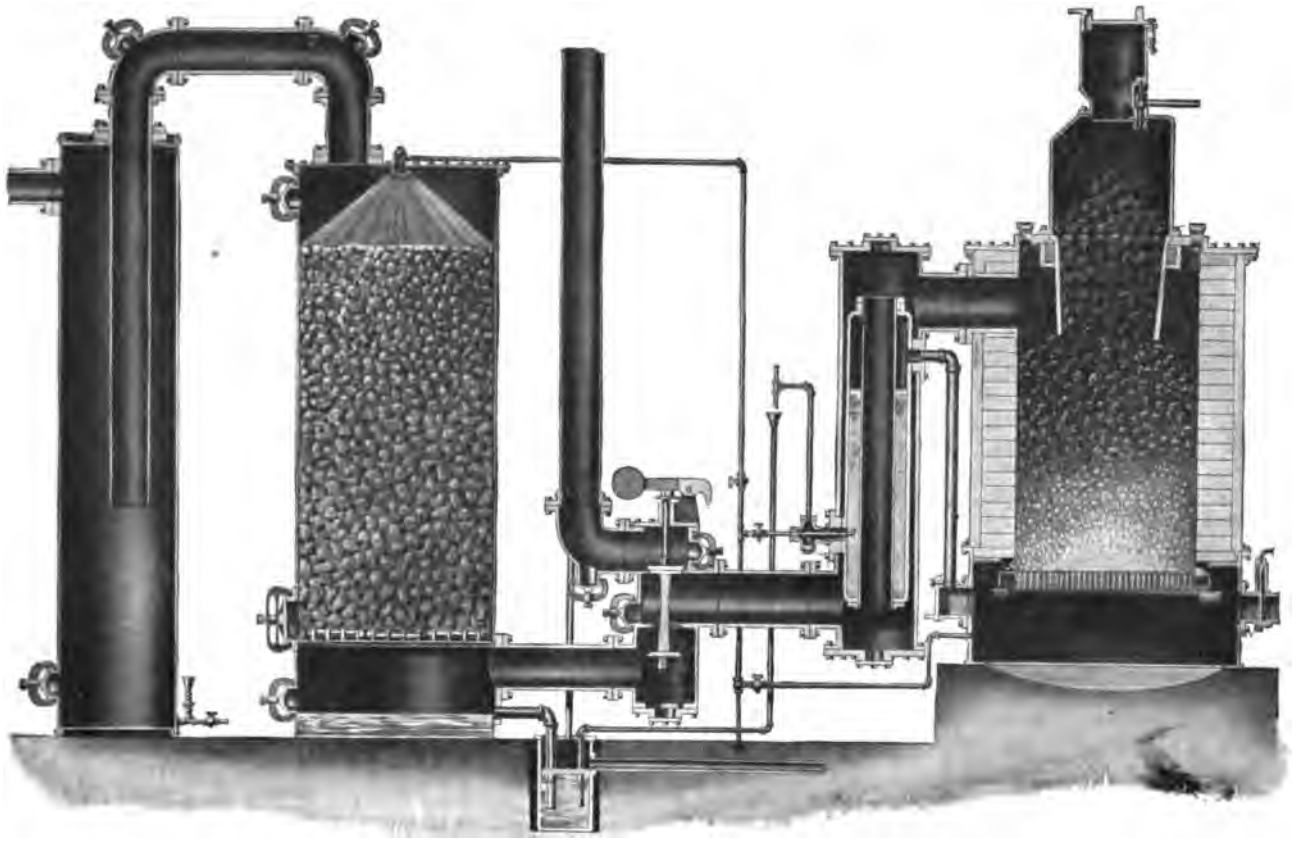


FIG. 4.—SECTIONAL VIEW OF FAIRBANKS-MORSE SUCTION GAS PRODUCER.

The stand-over loss with the suction producer amounts to about one-third as much as with a steam boiler. In other words, where the stand-over loss with a steam plant for fourteen hours amounts to 600 to 800 pounds, or more, with a suction producer plant of the same horse power this loss would not exceed 200 pounds.

ADVANTAGES OF SUCTION GAS PRODUCER POWER.

We have already discussed the high thermal efficiency of the suction gas producer plant. The most important and the most practical commercial advantage is the economy effected in the cost of developing power. If there were no other advantages, this one feature would be sufficient reason for installing this system. Other advantages may be summed up briefly:

The producer, in which fuel gas is generated from coal, is almost as simple as an ordinary furnace for heating purposes. The gas engine is entirely automatic in operation and needs little more than the ordinary cleaning and care as to lubrication.

There is no danger from explosion or from fire. It is absolutely safe, even in the hands of men with little mechanical train-

SUCTION GAS PRODUCERS.

A sectional view of a Fairbanks-Morse anthracite suction gas producer is shown in Fig. 4. Coal is admitted to the producer through a hopper at the top. This has double closure, so that the fuel can be introduced without at the same time admitting air. In the process of partial combustion which takes place producer gas is generated. The hot gas passes through a vaporizer in which a small amount of steam is formed, which, with a limited amount of air, passes under the grate of the producer. In

Lignite cannot be used in standard anthracite producers, but the Fairbanks-Morse lignite producer operates very successfully with this fuel. Gas from lignite averages 130 B.T.U. per cubic foot. This fuel can be fed to the producer in any size that will go through the charging hopper, and it causes no serious trouble from clinkers.

PRODUCER GAS ENGINES—VERTICAL TYPE.

These engines are made in sizes of 200 horse power and smaller. By combining several units, plants of 800 to 1,000 horse power or larger have been installed. A section view of the Fairbanks-Morse engine of this type is shown in Fig. 5. It may be of interest to note briefly a few of the carefully developed features in the design of these engines.

The present system of ignition is a great improvement over the methods formerly used. The make-and-break igniter is so constructed that it can be adjusted to spark as early or as late as desired, when the engine is running or at rest, by means of a convenient hand lever. A single lever controls the time of ignition for all cylinders. This is a feature of much importance, especially with producer gas, as it permits timing the ignition to give the greatest possible power and economy with any particular grade of gas, and when the engine is running. In addition, there is an independent adjustment for each igniter which is operated by a drop cam. The igniters can be removed, inspected, and cleaned, without interfering with other working parts. As the successful operation of a gas engine depends largely upon the igniter, the value of these features cannot be emphasized too strongly.

Both valves are mechanically operated from a single cam shaft, which is located inside the crank case. This minimizes the amount of noise, and furthermore the two-to-one reduction of gearing includes a pinion which is made of alternate layers of steel and red fiber. These features insure a quiet running engine.

The simple fly-ball governor is of a carefully designed pattern. It operates a balanced disk valve which is so constructed that there is no frictional contact or surface to become fouled by any impurities in the gas. This is especially important with engines operating on producer gas. The governor insures very close regulation, adapting the engine for electric lighting and other service requiring uniform movement.

Lubrication is effected by means of a single elevated oil reservoir, which is provided with a separate brass pipe with an individual sight feed for each bearing. The drip from the different bearings collects in the base of the engine, which is drained by means of a small pump. The oil is run through a filter and is then used over again.

Each engine is fitted with a hand-operated speed regulator, by means of which the speed can be reduced when the engine is running. One cylinder of each engine is fitted with an automatic compressed air starting gear. This can be thrown into or out of action by the movement of a single lever, and the engine can then be started automatically on compressed air.

FUEL CONSUMPTION TESTS.

A series of tests have recently been made on a 150 horse power Fairbanks-Morse engine and anthracite producer, for continuous runs of twenty-four hours, at one-quarter load, one-half load, three-quarter load and full load, the object being to determine the comparative economy at different loads. The coal used was an ordinary grade of "buckwheat" Pennsylvania anthracite, running rather high in ash, the analysis being as follows:

Fixed Carbon	78.9%	Moisture	2.7 %
Volatile	5.3%	Sulphur	0.77%
Ash	13.0%	B.T.U. per lb. as fired	13,590

Some of the results of these tests, including the coal consumption per brake horse power hour, are given below:

Load	B. H. P. on Engine	Speed R. P. M.	Coal in 24 Hours	Coal per B. H. P. per Hour	Cooling Water per B. H. P. Hour. Gals.	Steam per Pound of Coal. Lbs.
Full	149.4	224	3838	1.07	5.0	0.48
¾	113.1	216	3185	1.13	5.6	0.45
½	75.4	226	2369	1.3	6.8	0.41
¼	38.	228	1590	1.74	13.1	0.35

Economy tests have often shown a lower consumption than indicated above—frequently less than one pound of coal per brake horse power hour at approximately full load. The figures given are of value as giving the comparative fuel consumption at different loads, and for this purpose they may be considered as conservative and accurate.

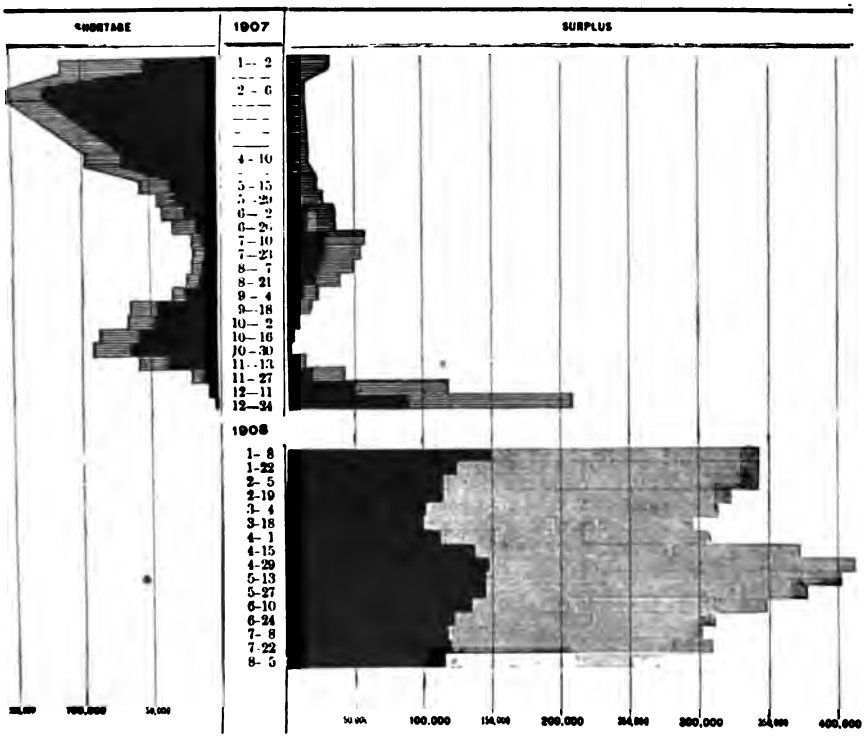


DIAGRAM SHOWING SHORTAGES AND SURPLUSES OF FREIGHT CARS AT FORTNIGHTLY INTERVALS SINCE JANUARY 2, 1907.

THE FREIGHT CAR SITUATION.

Statistical bulletin No. 29, issued by the committee on car efficiency of The American Railway Association, showed a total of 281,621 surplus cars on August 5, a decrease of 27,059 since the last fortnightly report. Of this decrease 6,505 are box cars, 21,195 coal and gondola, while surplus flat cars increased about 1,000.

Shop reports indicate an increase of about 5,000 in the number of bad order cars, leaving a net improvement of 22,000 cars. The increase in bad order cars is not necessarily an indication of lack of activity in car repairs, but is probably due to the transfer of cars from the available to the shop column on account of defects developing when cars are taken from storage tracks for restoration to service.

The accompanying chart shows graphically the surpluses and shortages as taken from the fortnightly reports since January 2, 1907. The black parts represent box cars and the shaded portions other types of freight cars.

APROXIMATE COST OF OXY-ACETYLENE WELDING.

Oxygen at three cents—Acetylene at one cent per cubic foot. Labor 30 cents per hour.

Tip Number	Thickness of Metal	Consumption of Acetylene Per Hour	Consumption of Oxygen Per Hour	Proper Pressure in Pounds for Oxygen	Lineal Feet Welded Per Hour	Cost of Labor Per Hour	Total Cost Per Hour	Cost Per Lineal Foot
1	1/32 to 1/16	2.8 feet	3.6 feet	8 to 10 lbs.	50 feet	.30 cents	.436	.0087
2	1/16 to 3/32	4.5 "	5.7	10 to 12 "	30 "	30 "	.516	.0172
3	3/32 to 1/8	7.5 "	9.7 "	12 to 14 "	25 "	30 "	.666	.026¢
4	1/8 to 1/4	11.7 "	15. "	14 to 18 "	16 "	.30 "	.867	.054
5	1/4 to 1/8	18. "	23. "	18 to 22 "	10 "	.30 "	1.17	.117
6	1/8 to 7/8	25. "	32. "	20 to 25 "	7 "	.30 "	1.51	.216
7	7/8 to 1/2	32.5 "	41.5 "	22 to 27 "	5 "	.30 "	1.87	.374
8	1/2 upward	48.5 "	62. "	24 to 30 "			2.64	

APPROXIMATE COST OF CUTTING STEEL.

Number Cutting Tip	Use Welding Tip No.	Thickness of Steel	Heating Jet. Feet of Acetylene	Heating Jet. Feet of Oxygen	Cutting Jet. Feet of Oxygen	Pressure of Oxygen Heating Jet	Pressure of Oxygen Cutting Jet	Lineal Feet Cut Per Hour	Labor Per Hour	Total Cost Per Hour	Cost Per Lineal Foot
1	4	up to 1/2"	12	15½	60	14 to 18 lbs.	125 lbs.	60	.30	2.68	.0447
2	4	1/2" to 1½"	12	15½	75	14 to 18 "	125 to 150	50	.30	3.13	.0627
3	5	1½" up	18	23	75	18 to 22 "	150 to 175	40	.30	4.02	.1005

not only effecting a very material saving in the cost of operation, but obtaining better results as well. An imperfect mixture of gases is not only much more expensive, but an excess of oxygen oxidizes the metal, and too much acetylene carburets it, either condition being seriously detrimental.

Railway companies are particularly interested. At one of the large railway shops, several repairs to locomotive boilers have been made, obviating the expensive removal of defective sheets. An extensive demonstration is being made at this shop, the results of which are being awaited by several other railway companies with much interest. Recently about twenty split boiler tubes were welded by this process, all of which were then burst by excessive pressure, but not one of them parted at the weld. Some months since, J. G. Stevenson, of the Baltimore & Ohio Railway Co., made some tests and obtained 94 per cent. of the original strength of cast steel and 88 per cent. of rolled steel. The experience in operation since has undoubtedly improved this kind of work.

In the railway shops, where these tests are being made, thermit is successfully used in welding heavy locomotive frames, but it is believed that the oxy-acetylene process can be used to great advantage in preparing the frames for the operation, and in cutting away the excess of very hard material afterwards. Recently about 70 feet of steel piling, running from 3/8 in. to 2¼ ins. in thickness, and a number of steel beams were cut in the construction of a building in New York. A 15-in. I-beam was cut in four minutes. Cast iron welded by this process rarely breaks in the weld. Cast iron welded to steel breaks in the original cast iron instead of where joined to the steel.

The development of this process is scarcely begun, and its field is almost without limit, but as previously stated, it is an art which will require intelligence, fertility, patience and experience to secure the marvelous results of which it is capable. Pure oxygen and acetylene and the best apparatus possible to produce them are absolute requisites. Short cuts, cheap apparatus and incapable operators are certain to retard progress greatly. Where the process is to be used over and over on the same kind of work, a conscientious operator of very ordinary ability, can, within a few weeks, become quite expert, but where a very large variety of work is to be performed, knowledge of metals, resourcefulness, personal interest and experience are indispensable.

A carefully prepared table, showing the approximate cost of cutting and welding is appended hereto, and will be found of much interest to investigators.

IMPROVED ROLLER BEARING.

A new Grant roller bearing has recently been produced by the Standard Roller Bearing Company of Philadelphia. The new bearing has conical or tapered rollers, but they are solid. The

IMPROVED GRANT ROLLER BEARING.

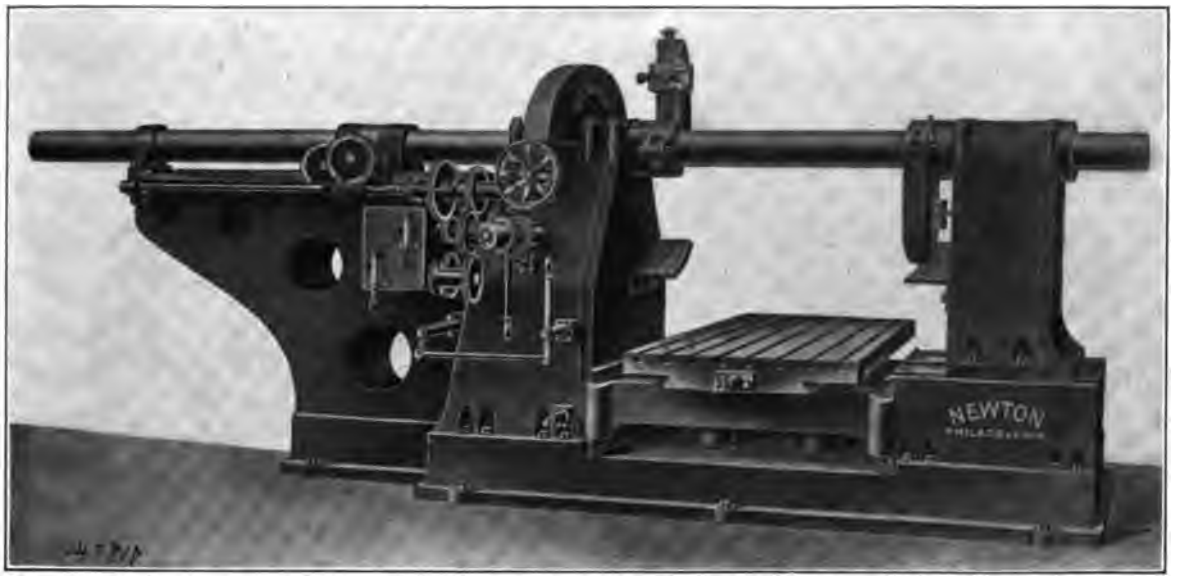
races and cones are made of special steel, with the temper drawn, so that they are very tough and will not chip or break under the most severe service.

The cage or retainer holding the rolls is made of the same general type as that used so successfully by the company for many years on its standard journal roller bearing; it consists of individual sockets or races, in which the ends of the rolls rest, and is made of solid steel with the two ends securely riveted together by a special electric riveter, giving the strongest form of cage or retainer that can be devised; the hot riveting makes the cage substantially solid or one-piece; it is impossible for it to twist or get out of shape, and, as there are no small journals or pins on the rollers, it makes an exceedingly strong bearing.

The cone has an especially wide shoulder, against which the ends of the rollers have a bearing, practically to the center of the roll, the shoulder having the same degree of bevel as the ends of the rolls. The entire thrust is taken in this manner, giving great durability and strength to the bearing.

The bearing is made interchangeable with other forms of conical or tapered roller bearings and its construction is such that it will carry a heavier overload than usual.

AMERICAN STREET AND INTERURBAN RAILWAY ASSOCIATION.—The annual meeting of this association will be held at Atlantic City, October 12-16. The secretary is B. V. Swenson, 29 West Thirty-ninth Street, New York City.



NEWTON SPECIAL CYLINDER AND VALVE CHAMBER BORING MACHINE.

CYLINDER AND VALVE CHAMBER BORING MACHINE.

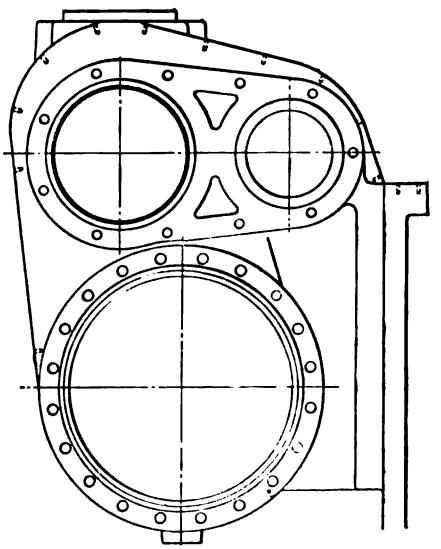
The accompanying illustration shows a special cylinder boring machine, designed by the Newton Machine Tool Works, Inc., Philadelphia, for boring any class of simple or compound engine cylinders and piston valve chambers at one setting. It is said that a simple cylinder and valve chamber can be bored in five hours. Where inclined cylinders are used an auxiliary table may be furnished which can be swiveled to bore at an angle of 20 degrees.

After a cylinder has been planed it is placed on parallel strips on the table of the boring machine, and by means of the vertical, transverse and longitudinal adjustments the high and low pressure cylinders and valve chamber of a compound locomotive may be bored at one setting. This insures the alignment of the cylinders, and by the use of gauges the proper distance between centers may be maintained. A typical example of the work which may be accomplished in this way is illustrated by the sketch.

The spindle has a speed range of from 4 to 15 r.p.m. and may be driven by either a four step cone pulley belt drive or a 20 h.p., 3 to 1 variable speed motor. The drive is connected to the spindle through a clutch, so that the spindle may be started or stopped without stopping the motor or countershaft. The motor is fitted with a fly wheel to overcome the shock of engaging the clutch. The spindle is 7 in. in diameter and is fitted with two splines for driving. It is ground and fitted in sleeves, one in each bearing. The sleeve in the main pedestal drives the spindle through a phosphor bronze worm wheel, 41 in. in diameter, and a hardened steel worm with a roller thrust bearing; the worm and worm wheel are encased and run in oil. The other sleeve is in the foot-stock or outboard bearing and is keyed to the spindle and revolves with it. Both of these sleeves are lapped in the hole for the spindle so as to insure a proper bearing, and are ground on the outside and fitted in brass bushings which are accurately scraped, a cap bearing being provided for compensating for wear.

To each of these sleeves is fitted a special design of facing arm, which can be engaged or disengaged without stopping the spindle motion; on each facing arm is fitted a tool slide, with in and out adjustment for setting the depth of cut; the tool slide has a feed in either direction on the arm, by means of star wheel and pins. The spindle is fed forward by a trolley or carriage, operated by a screw and nut, and has a continuous motion of 140 in. so that it can be entirely withdrawn for removing cylinders at a single transverse motion. The outboard, or foot-stock, bearing is adjustable by means of a rack and pinion to give a minimum distance between the facing arms of 45 in. and a maximum distance of 60 in.

The cross adjusting table is fitted with steel plates on the top, which gives a steel web to the T-slots and prevents the edges from breaking out; it also maintains the alignment of the top of the table. The table has both hand and power adjustment and is adjustable longitudinally on the knee in order to bring different lengths of cylinders central between the facing arms. The knee is accurately fitted between the bed, and is supported by four screws, 6 in. in diameter, which are used to raise and lower the table, and properly support it to give a minimum distance from center of spindle to top of table of 43 in. and a maximum distance of 51 in. The table is raised and lowered by power with a fine hand adjustment.



ILLUSTRATING WORK WHICH MAY BE BORED AT ONE SETTING.

Six changes of feed in either direction are supplied to the spindle through the gear box, the feeds amounting to 0.062, 0.100, 0.166, 0.333, 0.667 and 1 inch per revolution of spindle. The feed is engaged by the lever above the feed box, which when moved to the left engages the feed, and when moved to the right engages the quick traverse, both of these movements being reversed by the lever directly under the hand-wheel in front of the machine. The quick power motion in either direction is at the rate of 10 feet per minute.

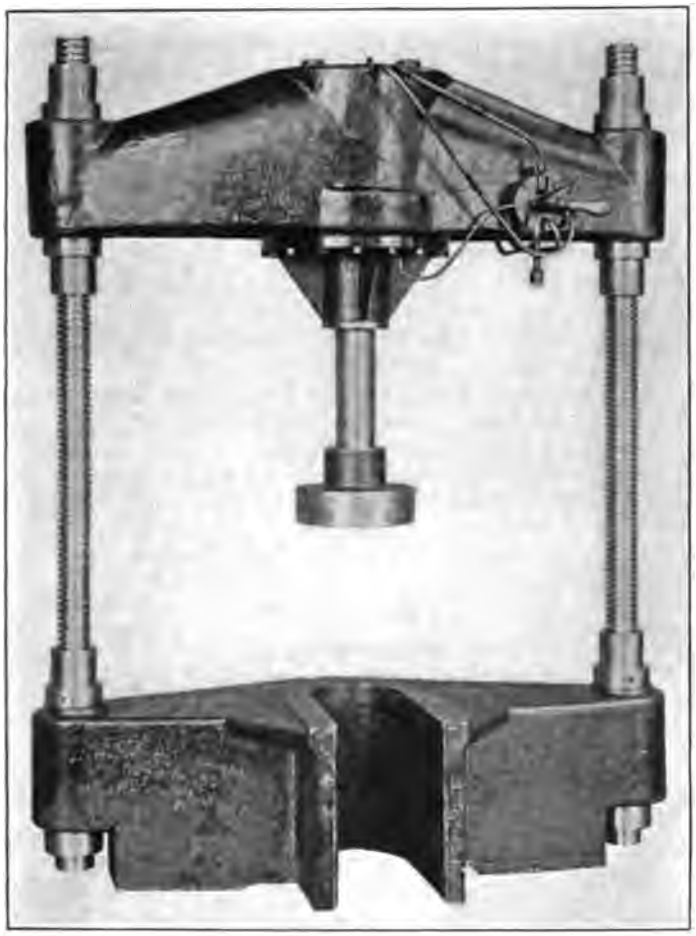
NATIONAL MACHINE TOOL BUILDERS' ASSOCIATION.—The regular annual meeting of this association will take place, October 20 and 21, in New York City. The headquarters will be at the Hotel Imperial, Broadway and Thirty-second street.

PNEUMATIC PRESS.

A recently designed pneumatic press, suitable for railroad shop work, is shown in the illustration. The Springfield Machine Tool Company, Springfield, Ohio, designed and built one of these presses for their own use; it proved so successful that the company has decided to manufacture and place them on the market. When supplied with an air pressure of 80 lbs. per sq. in. the press is capable of exerting a pressure of 8,800 lbs. An auxiliary air pump, not shown in the illustration, may be thrown into action, which increases the capacity of the press to 27,000 lbs. The base of the machine is of heavy construction and large enough to take a piece of work 40 in. wide.

The opening in the base casting extends back beyond the center of the machine and permits a portion of the work, such as a shaft or pin, to extend a considerable distance below the top of the base.

The upper frame casting contains in its center the air cylinder, 12 inches in diameter, the piston having an 8-inch stroke;



SPRINGFIELD PNEUMATIC PRESS.

if required the stroke can be made longer. The piston is fitted with three rings, which prevents air leakage. The lower end of the piston rod carries a heavy circular shoe, the central portion of which is filled with babbitt, so that the work will not be bruised when the pressure is applied. The two uprights are threaded to permit adjusting the upper casting to the height required by the work. By the use of the adjusting screws the press can be made to accommodate a great variety of work.

The control of the air for the cylinder is through a valve at the right-hand side of the upper frame casting. The valve is very simple in its operation. As it is moved from the left-hand position the piston is raised, while a further movement will shut off all the air; then by moving the handle still further in the same direction, the piston is lowered, which permits the full air pressure to be applied to the work. If the pressure thus obtained does not prove to be sufficient, a further movement of the controlling handle in the same direction throws into operation a small, quick-acting air pump, which is placed on the top of the upper frame, but is not shown in the illustration. This pump is capable of raising the pressure to 250 pounds, when the main line is supplied with air having 80 pounds pressure to the square inch. The valve allows a very sensitive adjustment of the piston in either direction, and is so arranged that the piston cannot move too rapidly.

16-INCH PORTABLE LATHE.

The 16-inch portable lathe, illustrated herewith, was designed by the Lodge & Shipley Machine Tool Company, Cincinnati, Ohio, for use in fitting frame bolts, turning studs, etc., in locomotive repair shops. The machine can be wheeled alongside the locomotive, upon which the work is to be done, and a considerable saving in time and strength can be effected over the practice of carrying the parts to be fitted to the lathe department. An 18-inch lathe used for this purpose at the Collinwood shops of the Lake Shore & Michigan Southern was described on page 91 of the March, 1907, issue of this journal and a 16½-inch portable lathe, used at the Angus shops of the Canadian Pacific Railway was described on page 35 of the January, 1908, issue.

The lathe bed is mounted on three wheels and may be pulled about by one man on a fairly level floor. The motor is of a 2½ h.p., fully enclosed, constant speed type and is suspended underneath the headstock and belted to a two-step cone pulley, mounted upon the back gear shaft. The class of work to be handled does not require a wide range of spindle speed and the

LODGE & SHIPLEY PORTABLE LATHE.

two changes, which are provided, are thought to be ample. The lathe is supplied with a belt feed of two changes, a power longitudinal feed and a plain rest. If desired it can be supplied with a taper attachment; legs can also be furnished in place of the wheels.

SIXTY-TWO STORY BUILDING.—Plans have been filed with the superintendent of buildings, of New York City, for a 62-story structure for the Equitable Life Assurance Society, to stand on the block bounded by Broadway, Nassau, Pine and Cedar streets. Including a tower, the building will rise to a height of 909 feet above the curb line, exclusive of a flagstaff, which will measure to the tip 150 feet more. The estimated cost is about $10,000,000. The design is by D. H. Burnham & Co., and shows that the main building will be of thirty-four stories or 489 feet, with a frontage of 167 feet on Broadway, 152 feet on Nassau street, 304 feet on Pine street and 312 feet on Cedar street. Above this building will rise a square tower of 28 stories capped with a cupola, the tower and cupola together to be 520 feet high. The main building is to be equipped with a group of thirty-eight passenger elevators built in two rows in a corridor finished in ornamental bronze. Eight of these will run to the top of the tower extension. No definite action has been taken as to just when the building will be erected.

WHAT THE RAILROAD CLUBS WILL DO IN SEPTEMBER.

Canadian Railway Club (Montreal).—R. E. Johnson, of the Canadian Fairbanks Company, Montreal, will present a paper on "Gas Producer Plants," September 1st, at the Windsor Hotel. Secretary, Jas. Powell, P. O. Box 7, St. Lambert, near Montreal.

Central Railway Club (Buffalo, N. Y.).—W. H. Evans, master mechanic of the International Railway Company, will read a paper on "Electric Traction vs. Steam Railroad Operation," Friday, September 11th. This is also the date of the fall outing of the club. A boat trip will be taken down the Niagara River, leaving at 10 A. M., and dinner will be served on Grand Island at 2:30 P. M. The return boat will reach the city at 7 P. M. The regular meeting of the club will be held on the boat en route. Secretary, Harry D. Vought, 62 Liberty street, New York City.

**Iowa Railway Club (Des Moines, Ia.)*—Meets September 11. Secretary, W. B. Harrison, Union Station, Des Moines, Ia.

New England Railroad Club (Boston).—Next regular meeting Ocotber 13th. Secretary, George H. Frazier, 10 Oliver street, Boston, Mass.

New York Railroad Club (New York City).—Raffe Emerson, assistant engineer of methods, Atchison, Topeka & Santa Fe Railway, will present a paper on "Handling Locomotive Supplies; Value of Proper Handling of Supplies; Supply Costs and Accounting; Design of Items of Engine Equipments; Methods of Handling Supplies and Equipments; Results," Friday, September 18th, at the Engineering Societies Building, 29 W. 39th street. Secretary, Harry D. Vought, 62 Liberty street, New York City.

**Northern Railway Club (Duluth, Minn.).*—Meets September 25. Secretary, C. L. Kennedy, 401 West Superior street, Duluth, Minn.

North-West Railway Club.—This club, of Minneapolis and St. Paul, has discontinued its meetings for the present season.

**Railway Club of Pittsburgh (Pittsburgh).*—Meets September 25. Secretary, J. D. Conway, P. & L. E. R. R., Pittsburgh, Pa.

**Richmond Railroad Club (Richmond, Va.).*—Meets September 10. Secretary, F. O. Robinson, 8th and Main streets, Richmond, Va.

**Rocky Mountain Railway Club (Denver, Colo.).*—Meets September 8th. Secretary, M. M. Currier, Box 229, Colorado City, Colo.

St. Louis Railway Club.—Prof. L. E. Young, director of the School of Mines and Metallurgy, Rolla, Mo., will address the meeting, Friday, September 11th. The exact subject has not yet been announced. Secretary, B. W. Frauenthal, Union Station, St. Louis, Mo.

Western Railway Club (Chicago).—Arthur Hale, chairman of the car service committee of the American Railway Association, will address the club on Tuesday evening, September 15th. Secretary, J. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

*Subject for discussion apparently not yet determined as no reply was received from the secretary up to the time of going to press. It is assumed that there will be no change in the time of holding the regular meeting.

UNIQUE ADAPTATION OF SHELBY TUBING.

At a banquet, recently given to the officials of the National Tube Company at Pittsburg, the dishes used were formed (not cast) from Shelby seamless steel tubing. As shown in the illustration, the material was hammered flat for the knife blade and spoon handles, was curved in or out for the bowls of the spoons

and for the plate and saucer, was left in its original shape for the napkin ring, was expanded at one end into several times its original diameter for the goblet, and was formed into a bell. It is said that over three hundred uses have been found for this tubing, and new uses are constantly being added.

PERSONALS

R. E. Fulmer has been appointed master mechanic of the Tremont & Gulf Ry., with office at Eros, La.

The office of the superintendent of motive power of the Mexican National R. R. has been transferred from Laredo, Tex., to San Luis Potosi.

W. C. Hayes, superintendent of the Erie at Susquehanna, has been appointed superintendent of locomotive operation, with headquarters in New York.

H. E. Lind has been appointed storekeeper for the Erie R. R. at Susquehanna, Pa., vice T. H. Keffer, resigned. H. J. Ackworth succeeds Mr. Lind as storekeeper at Kent, O.

R. B. Smith has been appointed foreman of motive power and equipment of the Cincinnati, Lebanon & Northern Ry., at Rendleton, O., succeeding John Stutter, resigned.

William Henry, assistant master mechanic of the St. Louis & San Francisco R. R., at Memphis, Tenn., has been appointed master mechanic with headquarters at Sapulpa, Okla.

William Baird, general car inspector of the Chicago, Burlington & Quincy Ry., has been appointed shop superintendent at the Plattsmouth, Neb., shops, succeeding H. J. Helps, resigned.

W. Hamilton, acting locomotive foreman of the Grand Trunk Ry., at Palmerston, Ont., has been appointed locomotive foreman at Stratford, Ont., succeeding J. A. Mitchell, resigned.

J. A. Mitchell, locomotive foreman of the Grand Trunk at Stratford, Ont., has been appointed locomotive foreman of the Grand Trunk Pacific, with office at Rivers, Man.

C. E. Gossett, master mechanic of the Chicago, Rock Island & Pacific at Armourdale, Kan., has been appointed master mechanic of the Iowa Central, succeeding T. M. Feeley, resigned.

G. W. Taylor has resigned as division master mechanic of the Atchison, Topeka & Santa Fe Ry., at Newton, Kan., to become superintendent of motive power of the San Antonio & Aransas Pass Ry., with headquarters at San Antonio, Tex., succeeding G. W. Butcher, resigned.

SECOND ANNUAL CONFERENCE OF THE APPRENTICE INSTRUCTORS, NEW YORK CENTRAL LINES.

The second annual conference* of the apprentice instructors of the New York Central Lines took place at Depew, N. Y., September 3. In addition to C. W. Cross, superintendent of apprentices, Henry Gardner, his assistant, and the instructors whose names are shown on the accompanying table, the following guests were present: C. H. Hogan, division superintendent of motive power; F. M. Gilbert, mechanical engineer; F. W. Thomas, supervisor of apprentices, Santa Fé., and Henry Maxwell, educational instructor of apprentices in the locomotive department of the Canadian Pacific Railway Company at Angus Works. At the opening of the conference letters were read from J. F. Deems, L. H. Turner and G. M. Basford. Following are extracts from these:

Drawing Instructor.	Shop Instructor	Shop.
A. W. Martin	W. J. Greilich	Beech Grove, Ind.
R. M. Brown	H. J. Cooley	Collinwood, O.
G. Kuch, Sr.	G. Kuch, Jr.	Depew, N. Y.
F. Deyot, Jr.	L. T. Johnson	East Buffalo, N. Y.
C. A. Towsley	M. T. Nichols	Elkhart, Ind.
C. P. Wilkinson	C. T. Phelan	Jackson, Mich.
V. J. Burry	J. R. Radcliffe	McKees Rocks, Pa.
H. S. Rauch	F. Hanley	Oswego, N. Y.
H. R. Martinson	H. R. Martinson	St. Thomas, Ont.
A. L. Devine	F. Nelson	West Albany, N. Y.

Mr. Deems.—"There is no more important problem now confronting the railroads, and especially the mechanical department of railroads, than the future relationship between the employees and the companies. You are engaged in the work of the systematic training of apprentices in the theory and the practice of the trades, to raise the standard of mechanics in the shops, for the mutual benefit of the company and the employees.

"The value of this plan of training apprentices may not be apparent in the first year of apprenticeship, but later it is shown there is a very decided benefit to the apprentice himself, as well as the company, and in time this must be reflected in the community.

"Those of us who have served an apprenticeship under the old régime know the difficulties we had to overcome in learning the trade. It is believed the apprentices on our lines fully appreciate the privileges afforded, as is evidenced by the eagerness and ambition displayed on their part, which is commendable to both the instructors and the apprentices.

"The relation of both the drawing instructor and the shop instructor to the local organization is especially important, he should make every effort to impress on all concerned that his efforts are co-operative with the object of increasing the output and efficiency of the shop in general."

Mr. Turner.—"I cannot refrain from saying to you that I am very much impressed with the work that is being accomplished, which is sure to result in building up a much better class of mechanics on the Lines; also a better class of men to draw from when men are to be selected to take supervisory positions. You are to be complimented on the splendid work you are doing."

Mr. Basford.—"It would be a great pleasure to me to meet the men who are working out the details of a plan which seems to be one of the most important movements of the time in the most important problem of the time—transportation.

"For many years I have dreamed of seeing apprenticeship worked out practically on a large scale, as you are working it out, and that the dream has come true is almost too good to believe.

"What does it matter if the work involves a good deal of drudgery? Is there any work worth while which does not involve it? I think that everything should be said and done to encourage those who are carrying the burden of this effort. The most encouraging thing that I can think of to say is that there is nothing in any industrial or transportation organization which begins to approach in importance and in the possibilities of far-reaching results, this preparation of recruits who are to be the men of the future. I think you should bear in mind the fact that the New York Central Lines were first in the field in a broad effort of this sort. Remember that other railroads are watching and following you and that it will be necessary to be alert and active in order to maintain the lead which you now hold. The best of success to you and to all who are helping you in this development which has been so ably organized by Mr. Deems."

C. H. Hogan, Div. Supt. M. P., then spoke in part as follows: "We see here at Depew Shops the results of the labor of the apprenticeship department. The company has incurred the expense of installing the school and providing for the practical training of apprentices—to educate them to become skilled mechanics. At first the apprentice may not think much of the training he is being given, but at the end of the fourth year he will say that he would not have gained the theoretical knowledge and thorough practical training if it were not for your efforts, and he will show his gratitude for the opportunity given him. The other day a professor from one of the high schools of Buffalo visited our school and shop and expressed his surprise that the railroad company took so much interest in their apprentices and stated he would like to have all his instructors visit our school."

Mr. Cross' Address.—Mr. Cross then addressed the conference. He directed attention to the rapid extension and progress of modern apprenticeship methods on railroads throughout the country and reviewed the work of the apprenticeship committee at the last meeting of the Master Mechanics' Association. He closed with the following remarks:

"The testimony of all subordinate officers and others who are in a position to know, is to the effect that the company is deriving benefits from the training of apprentices and that the apprentice work is on a conservative and substantial basis. The shop instructor increases the efficiency and consequently the output of the apprentices by his instructions, and the drawing instructors increase their knowledge and efficiency by the instruction given in drawing and mathematics.

"The New York Central Lines plan of apprenticeship is intended to provide for recruiting the service by combining the shop instruction with the theoretical training. We feel that the work has now passed the experimental stage and has become a regular part of the work of the railroad. The value of this plan of training is that it enables the company to reap an immediate, as well as an ultimate benefit from the work done by apprentices, due to the special training they receive both in the school room and the shop. The aim is to have a light crop over a large area, rather than a phenomenal growth of a few plants. The progress made during the year indicates a substantial growth of the ideas of apprenticeship for recruiting the service. The apprentices everywhere acknowledge by their earnestness their gratitude for the opportunity offered for self-improvement. The interest displayed by the apprentices so far is very gratifying, and is increasing in proportion as the facilities for experimental work are increased and the plan of instruction is extended."

*An abstract of the proceedings of the first annual conference will be found in the November, 1907, issue of this journal.

A good feature in teaching this class of work is that the boy has the actual experience of seeing how the apparatus is constructed, as the lesson sheets require him to give dimensions of various parts, which necessitate taking the machine apart. After doing this he is requested to write an explanation, illustrating it with sketches, of the action of the air or water from the time it enters the pump until it is discharged into the atmosphere or reservoir. When the boy has had this experience we remove some part of the pump, without his knowledge, either leaving it out entirely or replacing it with a defective part. He is then put to work tracing the trouble and is told that he must locate it without taking the pump all apart.

Most of the apparatus used in the corner referred to was scrap, and was put in good shape by the boys during regular class hours. This work included cleaning, repairing, making new parts, assembling, installing and all pipe work. The boys are deeply interested in this work and take considerable pride in what they have accomplished. Thus far we have had no trouble in carrying on this work in the same room with the drawing class.

A. L. Devine.—We now have in the school laboratory at West Albany, for demonstrating purposes, the following apparatus: 4½ x 6 in. stationary engine, 22 in. engine lathe, gear rack, Walschaert valve gear model, partial section of 9½ in. air pump, bell ringer, safety valve, indicator and spring balances and sticks for leverage examples. The engine, which is operated by compressed air, runs the lathe by means of pulleys and belts.

Problems have been furnished us for work on the lathe, engine, gear rack, valve gear model and spring balance. These are done during school hours and corrected by the instructor, or one of the advanced boys, before the end of the exercise. Whenever possible we have the boys work in pairs on these problems. This work appeals to the ambitious apprentice, giving him more confidence in himself by working out the problems experimentally, breaks the monotony of the routine work and relieves the instructor to some extent. With an average attendance of thirty boys it is almost impossible for the instructor to devote any time to this class of work, and we have assigned one of the leading boys to take charge of everything but the drawing.

The valve gear model was made in the shop by a cabinet maker assisted by an apprentice; the forgings for the gear rack were made by a blacksmith apprentice and finished by a machinist apprentice. Two machinist apprentices removed quarter sections from several of our larger models to allow for a better view of the interior. With the exception of the valve gear model, all of the above work was done on the boys' own time.

Discussion.—At Oswego a machine has been constructed for testing the strength of materials.

The Use of Sketch Books.

H. S. Rauch.—I believe the sketch book to be one of the most valuable acquisitions we have made, for the reason that it teaches the apprentice how easy it is to omit an important dimension, or note, at a time when he cannot go back and get the information without cost to the company. The boys must be made to appreciate the fact that they are expected to get all necessary information when they are making the sketch. As to the proper time to begin sketching, it seems to me that the first model would be too soon. I think that the boys should learn the principles of drawing, the arrangement of views, etc., first. This, of course, will take some boys longer than others, so if the starting point for sketching is fixed we will have to delay it long enough for all to get a fundamental knowledge of mechanical drawing. My experience has been that it takes from ten to twenty-five plates to do this, and sometimes more. I believe that we should begin sketching much sooner than has been the general practice. At Oswego it has been our custom to begin with the seventy-eighth plate, which results in the boys having so much to think of on a "hurry up" sketch that they are liable to overlook many dimensions, whereas if they begin, say on the twentieth plate, the work will be much more simple and they will grow up with it, so that by the time they complete their course, sketching will have become second nature to them.

G. Kuch, Sr.—The use of note and sketch books was fully carried out at Depew about one year ago and good results were obtained. Apprentices were requested to sketch parts of engines, etc., draw the plan, side views, elevation and sections and add all necessary dimensions. They could then return to the drawing board and make a complete scale drawing from the sketches.

The use of note and sketch books should be enforced. Apprentices who have passed all examinations and have served six months, should obtain a note book, 2-ft. rule and soft pencil. They should then be required to make sketches and notes wherever possible. The instructor should see that these rules are enforced.

Sketching should not begin with the first model but after the twenty-fifth or thirtieth drawing. Ability to make sketches is a benefit to the company, the boys do not ask so many questions of the foreman and take his time from other important duties.

Should a Preliminary Sheet of Lettering Be Used?

C. A. Towsley.—I would suggest that a preliminary sheet of lettering be introduced into the course and that one sheet at least, and as many more as deemed necessary and advisable by the instructor, be required of each apprentice. Only about one-quarter of the new apprentices are able to do a creditable job of lettering and their ability is usually shown on the first drawing plate. Lettering is a knack that all cannot acquire, even with practice. The other three-quarters would be better off with several hours, or days if necessary, of practice in lettering or until it is evident that they have thoroughly mastered the work.

It is noticeable that a boy who is poor in lettering does not improve as rapidly as in drawing. The reasons are that the amount required is not equal to the amount of drawing, and because lettering is considered drudgery and is distasteful. Nothing detracts more from a drawing than badly formed letters and figures, and for that reason alone, extra precautions should be taken to bring them up to a standard of perfection.

Study of English.

Henry Gardner.—I am thoroughly in favor of the proposition to introduce instruction in the use of English into the fourth year of the apprentice school course.

In practical life the ability to speak and write clearly and effectively is necessary to success. No matter how thoroughly a foreman understands his work, if he is unable to make his men see his methods clearly, he is very much handicapped and cannot have the same hope for advancement which he otherwise would. A mechanic may have an application to make for a change of position or an increase of pay. If he can set forth his demands correctly and concisely, he will be more likely to gain his point than one who cannot. Inspectors and enginehouse foremen are frequently required to make reports to the master mechanic relating to repairs needed on locomotives and cars. A man having the ability to make this report brief, clear and intelligent, to state in good English the necessary information, will add to his chances for promotion.

The instruction in English should include letter writing and composition. I would suggest the following method for instructing boys in letter writing. Begin by requiring each boy to write a short letter upon some common, everyday subject and hand it in for criticism. To make this work more attractive it might be well, at times, to have two or more boys write letters upon the same subject. The instructor should then read the letters aloud to the boys, making a general criticism and comparison. Later, when proficient, it would stimulate interest to have some boys exchange letters and each criticize the letter written by the other.

The instructor should see that letters are written in well chosen, grammatical language, with a logical sequence of ideas, properly paragraphed and punctuated, and above all, each word correctly spelled. He should be careful, however, not to follow too closely the laws of composition. A boy with some origi-

A good-sized heating furnace to admit the largest car sheet and to accommodate about five thousand pounds of various kinds of plates, end sills, etc., is another necessity. A furnace with inside dimensions of 2 ft. 4 in. x 8 ft. x 13 ft. will accommodate this amount of material. By keeping in stock a sufficient amount of new standard parts it will not be necessary to keep the furnace in constant use. I have worked very successfully by using new material to replace damaged parts, allowing the damaged parts to accumulate until there was a sufficient amount on hand to justify heating the furnace, and find it more economical to manage it this way. All material which is straightened or repaired is placed in stock to be used on the next cars that come in. In front of the furnace an iron working plate about 5½ in. x 3 ft. 3 in. x 10 ft. should be placed with the necessary clamps for holding the bent parts in place while they are being straightened.

In every steel car shop, where there is sufficient work to warrant it, there should be an overhead crane for lifting the cars onto trestles instead of jacking; it can also be used for placing and holding the plates until secured by the workmen. By using a crane a couple of men on the ground will handle the largest plates used, otherwise a scaffold and a number of men are necessary to raise a plate and fasten it, accompanied by more or less danger to the men.

Organization.

When equipped, as outlined, I have found that on the heaviest of steel car repairs two men are able to handle most of the repairs, but find it practicable to place a gang of six men on three cars and by dividing them into three gangs they can do their own cutting apart, fitting up and riveting, and not be detained by material, which in the meantime is being straightened or machined. I have operated separate gangs to cut apart, fit up, and rivet, but with little success, for it is immaterial to the men who cut apart as to what becomes of the parts removed, and the gangs following lose considerable time in locating the parts when needed. It is also practicable to have stationary rivet heating furnaces in the car shop, placed so that each furnace can supply rivets to three gangs of six men each.

Painting.

Painting of steel cars is of the utmost importance, and where we have a great number of them, the repainting process is continuous. A suitable freight car paint shop should be provided, for the painting cannot be done outside in inclement weather. When equipment needs painting you cannot afford to neglect it until favorable weather comes. As a rule, in the summer months the equipment is busy, and there is little opportunity to withdraw it from service, except in cases of emergency. Newly built cars, when ready for the first painting, should have all the flash and rust removed. Unless this is done the flash and paint will continue to fall off in spots as long as any flash remains. In order to remove the flash thoroughly I would recommend the sand blast process. When it is not possible to use this method, would suggest dry cleaning, using steel scratch brushes, sand stone, or any tool which will answer the purpose. Following either process would suggest the application of three coats of paint at twenty-four-hour intervals. Later on, when repainting is necessary, the sand blast should again be used. If this cannot be done, dry clean, and apply two coats of good paint. After taking these precautions to protect the exterior, we find that under ordinary conditions it is necessary to repaint at the expiration of about three years; where conditions are unfavorable to the equipment, the repainting should be governed accordingly.

I cannot be too emphatic as to the necessity of taking the proper care of the exterior, and regret that the interior cannot receive the same attention, but occasionally spraying the interior with crude oil may be found beneficial. At the present time the P. & L. E. R. R. are testing this idea, and I am very sorry the test is not completed so as to enable me to give you the results.

The best of paint should be used in order to prevent rust after painting. The paint which has the greatest wearing elasticity is preferable, as there is less liability for the penetration of moisture. Adhesion is just as important, and to have perfect adhesion the paint should dry from the inside out, the same as good varnish. By using the best materials we need not fear the expansion and contraction of the plates as long as the elasticity remains.

Cost of Repairs.

Following are some data showing the relative cost of repairs to steel and wood cars, which I am confident is correct so far as it pertains to the P. & L. E. R. R. equipment repaired on its lines:

100 WOOD CARS REQUIRING HEAVY REPAIRS.

Cost of material	$2,521.00	Average per car	$25.21
Labor and supervision	1,631.00	" " "	16.31
Total	$4,152.00	Total	$41.52

100 STEEL CARS REQUIRING HEAVY REPAIRS.

Cost of material	$3,424.00	Average per car	$34.24
Labor and supervision	2,292.00	" " "	22.92
Total	$5,716.00	Total	$57.16

A very accurate record was kept of the average number of times the different classes of cars were called into the shop for light, medium and heavy repairs, covering a period of one year.

Average number of times one wood coal car was in shop during one year	7 times
Average cost of repairs each time in shop	$16.23
Average number of times one wood coke car was in shop during one year	6 times
Average cost of repairs each time in shop	$10.74
Average number of times one steel car was in shop during one year	1 1/8 times
Average cost of repairs each time in shop	$6.74

The above figures represent the cost of material and labor, less scrap credits, and is the average cost of the total repairs to:—

806	Heavy	steel	car	repairs,	
1,353	Medium	"	"	"	
9,180	Light	"	"	"	
11,338					
707	Heavy	wood	coal	car	repairs.
513	"	"	coke	"	"
3,018	Medium	"	coal	"	"
3,364	"	"	coke	"	"
12,488	Light	"	coal	"	"
12,040	"	"	coke	"	"
32,070					

Your attention is called particularly to the number of times a steel and a wood car are called into the shop per year, and to the difference in the cost of maintenance per car. Of course, it must be understood that when the time comes to renew the steel car parts which are worn out, the figures shown will be inadequate for the reason that we are comparing steel cars with a collection of new and old wood cars, but even so, I believe, if we give the steel cars the proper care their maintenance will be less in the end than that of wood cars.

Skill with the Scoop means economy in the use of fuel, but better still, it means a good steamer, while a lack of knowledge makes a poor steamer. It takes steam to move trains and plenty of steam means quick dispatch, which is a much-neglected form of economy in these days of heavy tonnage trains that move so slowly that they tie up the road and keep the yards blocked.—*C. B. Conger before the Traveling Engineers' Association.*

Cables of the Manhattan Bridge.—The cables of the new Manhattan bridge which is now in course of construction will consist of 9,472 steel wires, each being slightly over 3/16 in. diameter. This will make the finished cables about 21½ inches diameter. Each wire has a tensile strength of about 6,000 lbs., making the strength of each cable over 28,000 lbs. There are to be four of these cables in the bridge.

15-INCH SINGLE GEARED CRANK SHAPER.

The American Tool Works Company, of Cincinnati, has recently brought out a new 15 in. single geared crank shaper which embodies a number of important improvements. Some idea of the capacity of this machine may be gained from the following data from tests made at the works.

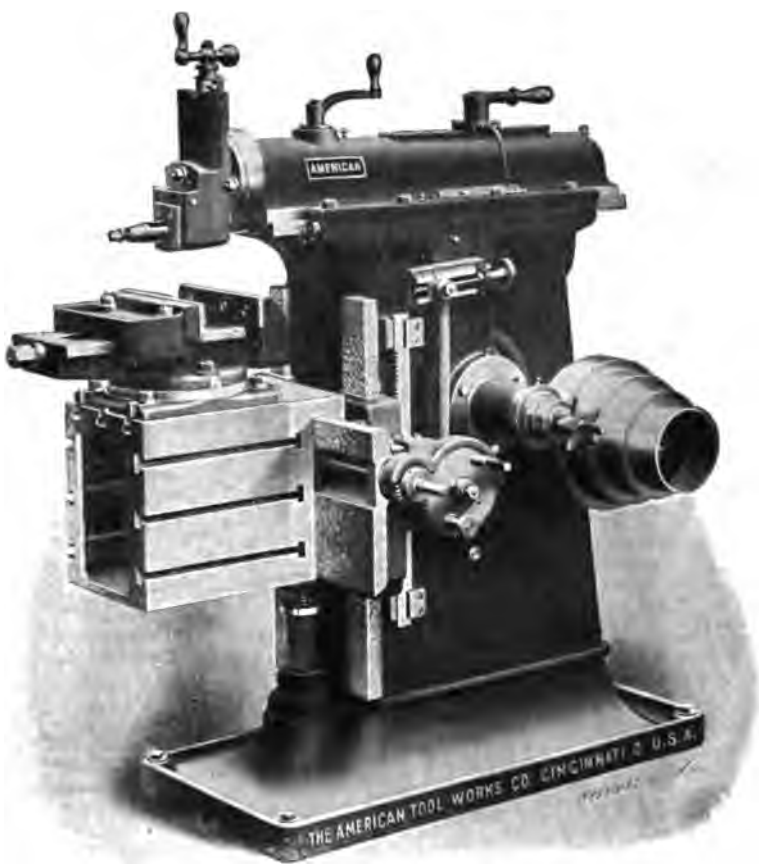
CAST IRON TEST.

1/16"	deep,	.016	feed,	2	notches,	4"	long,	30	strokes	per min.
1/8"	"	.040	"	5	"					
1/16"	"	.048	"	6	"					
1/8"	"	.024	"	3	"	12"	"	20	"	" "

STEEL TEST.

1/16"	deep,	.016	feed,	2	notches,	2½"	long,	30	strokes	per min.
1/8"	"	.016	"	2	"	10"	"	20	"	" "

The shaper is of heavy and substantial design to meet the most severe requirements. The stroke of the ram is positive



AMERICAN SINGLE GEARED CRANK SHAPER.

and has four rates of speed ranging from 20 to 65 strokes per minute. The length of the stroke may easily be changed without stopping the machine. The device for positioning the stroke is located on the ram near the head and may be manipulated while the machine is in operation. The pointer on the ram and an index indicate the length of the stroke. The rocker arm, of rigid and heavy construction, is so arranged as to give the ram a practically uniform rate of speed during the entire stroke; it also provides for an exceedingly quick return. The driving mechanism is sufficiently powerful for the heaviest work adapted to this type of machine.

The cross feed is of a new patented design, is variable and automatic, and has a range of from .008 to .200 in., any one of the feeds being instantly obtainable while the machine is in operation. It is supplied with a pointer and graduations either side of zero reading from 1 to 25 notches, each notch representing .008 feed. The feed mechanism is so constructed as to render unnecessary any adjustment due to a change in position of the rail. The feed may be thrown in or out or reversed through the knob on the large feed gear. This gear is also supplied with a square rod to receive a crank, by which the table may be quickly advanced or returned.

The column is deep and wide, slightly tapering toward the top, and is carefully braced and reinforced internally, so as to make it very rigid. It projects at the top at both the front and the rear, providing a long bearing for the ram. The base is deep and strongly ribbed and of pan construction to catch all oil drippings, thus protecting the floor. The ram is carefully designed to afford uniform rigidity throughout the length of the stroke and has large bearings on the column with a continuous taper gib, having an end screw attachment for taking up wear. The head may be operated at any angle within an arc of 100 degs. The down slide is fitted with a continuous taper gib having an end screw adjustment for taking up wear. The down feed is of unusual length, the feed screw having an adjustable graduated collar reading to .001 in. It is equipped with a large tool post for using holders with inserted cutters.

The table is of substantial construction and is readily detachable. The apron is provided with a continuous taper gib having an end screw adjustment for taking up wear and has T slots for clamping work when the table is removed. An automatic stop releases the feed and thus prevents breakage when the tool is fed into the cut or if the apron should accidentally be fed to its limit in either direction. The cross rail is of box form, is of exceptional length and provided with a large diameter telescopic elevating screw, having a ball bearing thrust bearing.

The rocker arm is of double section at the top, and this, in connection with an opening in the column, permits the key-seating of shafts as large as 2½ in. in diameter. Larger shafts may be key-seated by setting over the table and setting the head at an angle. Special attention has been given to the lubrication of all parts. The ram slides are provided with felt wipers at both the front and center of the column, assisting in perfect lubrication, also preventing oil from dripping down over the front of the machine. An oil pocket is cast integral with the column at the rear, storing any waste of oil, which may be drawn off at any time through a pipe extending from the rear of the column. A large quantity of oil is stored in a pocket cast integral with the arm with suitable means of distribution, insuring thorough lubrication of the crank pin and the sliding block in the rocker arm. The maximum length of stroke is 15¼ in.; the down feed to the head is 6 in.; the vertical travel of the table is 14 in.; the horizontal travel is 18 in.

SKILL IN HANDLING THE REVERSE LEVER AND THROTTLE gets as many heavy trains in on time as big locomotives carrying a high steam pressure. Skill with the injector counts for as much as skill with the scoop if the steam gauge is any guide.—*C. B. Conger before the Traveling Engineers' Association.*

MECHANICAL DRAFTSMEN WANTED.—The United States Civil Service Commission announces an examination on October 21 to 23 inclusive, to secure eligibles for the position of skilled mechanical draftsman in the ordnance department. The salary to start with will be from $1,000 to $1,200 a year. Application should be made to the United States Civil Service Commission, Washington, D. C., for information concerning the examination. It will be necessary for the applications to be properly executed and filed before October 10th.

RAILWAY SIGNAL ASSOCIATION.—The twelfth annual convention of this association will be held in the New Willard Hotel, Washington, D. C., October 13, 14 and 15. A booklet is being issued by the secretary, C. C. Rosenberg, 12 Linden street, Bethlehem, Pa., which includes the program for the meeting, a list of the members of the different committees and a complete list of all members of the association with their positions and addresses.

ing is invaluable as developing facility for easy speaking when on the floor and taking part in debate.

C. A. Seley.

Rock Island Lines, Chicago, Ill.

Editor's Note.*

Mr. Seley's suggestion is a splendid one. The railroad clubs can be used to considerable advantage by the ambitious young man, in assisting him to extend his acquaintance and to some extent to show his associates and superiors the kind of stuff he is made of. Many motive power officials can show how taking part in the work of the railroad clubs, or writing for the technical press, has been the direct means of assisting them to secure advancement.

A young man should never attempt to take part in a railroad club discussion on the spur of the moment, unless he is thoroughly familiar with the subject. It must be remembered that while it is possible to create a favorable impression by good logic, clear cut expression and evidence of a thorough knowledge of the subject under discussion, it is just as much of a disadvantage if the subject is not handled properly.

It is always advisable to prepare a written discussion beforehand. This may be read, although, if possible, it is better to use such notes as a guide and to speak extemporaneously. The advantage of writing the discussion beforehand is that it crystallizes the subject in one's mind. No matter how simple a piece of work you may perform if you attempt to write a description of it you usually find that you have yet much to learn concerning it, and often are led to see where you could make a great improvement.

In this connection the suggestion might be made that the club secretaries should try to issue the advance papers as much as possible in advance of the time of meeting. Under present conditions, in some of the clubs, the advance papers are received so late that it is almost impossible to give the proper amount of time to studying them before the meeting. The result might be not only to make it possible to have the young men take part more generally, but some of the older members would come to the meeting with a clearer idea of the subject under discussion and would not waste the time of the club by talking to cross purposes. At same time it would make it possible for the speaker of the evening to present the subject in brief abstract, allowing more time for a thorough discussion.

Rapid Ore Handling.—There are four machines at Cleveland, Ohio, for unloading ore vessels which can accurately weigh and deliver a car load of ore from vessel to car in about seven seconds.

Evening Classes at Columbia.—Columbia University will, during the fall and winter, offer twenty evening courses especially adapted to the needs of technical and professional workers. These include work in applied mechanics, applied physics, architecture, electricity, fine arts, industrial chemistry, mathematics and surveying and structures. The work will begin on October 26 and will continue for twenty-five weeks. A full description of the courses is contained in the "announcement of extension teaching," which may be obtained on application to the director of extension teaching, Columbia University, New York City.

Total Power Used in United States.—Using the data furnished by the census returns of 1900, 1902, and 1905 as a basis and applying the prevailing rate of increase in the industries included in these reports, and adding an equivalent amount for the steam railroads, it is estimated that the total installed capacity of prime movers in all our land industries for the year 1908 approximates 30,000,000 h.p. The average load on steam and other engines is much less than their rated capacity, and, owing to the overlapping of loads, it it probable that the total average load does not exceed one-third or one-quarter of this amount.—*H. St. Clair Putnam at the Conference on Natural Resources.*

* See also December, 1907, issue, page 473.

SUGGESTIONS AS TO AN IMPROVED SYSTEM OF BILLING FOR REPAIRS UNDER M. C. B. RULES.

To the Editor:

Referring to a suggestion which has been made looking toward doing away with the complicated system of billing for repairs under the M. C. B. rules by billing for repairs at an average cost per mile, or per day, as the rental is billed for. There seems to me to be serious objections to this. In the first place, it might be difficult to arrive at a rate per mile, or per day, which would be satisfactory to all the interests concerned.

Presuming that this difficulty was overcome there would remain the seemingly unanswerable objection that such an arrangement would inevitably lead to a neglect of equipment; it would be to every one's interest to get rid of cars with existing defects rather than to repair them. At the present time, I believe that under the M. C. B. rules, while it is not probable that any road can make any money by repairing foreign cars, yet in most cases there would be such a small loss that in general the tendency is to repair all defects as soon as possible after their happening. This is a factor which must be considered as of great value. Under the proposed change of the rules, the general tendency would be to try to dispose of cars to connecting lines with all the existing defects they could be made to stand for. This would not seem to be a desirable state of affairs.

There is another way of doing away with all the expensive routine of billing for car repairs, and while there are serious objections to it, it seems to me that it would dispense with a great deal of the red tape of the present rules without the attendant difficulty of tending to prevent a general habit of keeping foreign cars in a reasonably good state of repairs. My idea would take us back to the old rules, and about as far beyond them as the present rules are developed on the side of the owner being responsible for all except wreck damage; for although the rules make a good many exceptions beside actual wreck damage, it is altogether probable that there are "adjustments" which manage to throw almost all defects into the "owner's" class unless they are so serious as to be beyond question due to a wreck.

Now, if the rules should be changed so as to make the delivering company responsible for all defects on a car, matters would then be in a condition where the road which was handling the car would prefer to make the necessary repairs rather than to give its defect card to the connecting road when the car was offered in interchange, and the road receiving a car carrying a defect card would be likely to repair that car at the expense of the delivering road, rather than let the defect continue, with the probability of causing further damage for which it would be responsible.

The most patent objection to this method would be the fact that at present prices it would be in many cases to the advantage of the delivering road to issue its defect card because at present M. C. B. prices it would be probably cheaper to depute the work to some one else rather than to do it themselves. My plan would therefore involve the increasing of the M. C. B. prices to such a level that there would be a profit of 15 or 25 per cent. to the road which made repairs under the rules, on the authority of a defect card. It would then be to the advantage of the delivering road to make the repairs itself, except under special circumstances, and then the road which did the work would profit at the expense of the road which did not repair the defects for which it was responsible.

A feature of this plan would be that roads which borrowed more equipment than they loaned would probably be at a disadvantage, while roads whose borrowing did not exceed their loaning would break even; roads which were loaning more than they borrowed would probably be at somewhat of an advantage, as compared with present practice, and this would not seem to be an undesirable feature.

The only serious disadvantage that I can see in this plan is that there might be a tendency on the part of car owners to neglect the condition of their own equipment, but since they would be responsible to a road to which they should deliver a

and likewise terminate at the bolster. This makes a strong platform—very strong; in fact, much stronger than the car between the bolsters. The idea evidently in the mind of the designers of this form of car was that the bolsters should distribute the load put upon them by these sills to the intermediate and side sills, as well as the center sills.

The intermediate sills may act as a fulcrum and the sides get no load whatever, or the sides act as the fulcrum and then they become reaction points and thereby impart loads to the other sills. This case can be summed up as follows:

If the bolster had no deflection in the transverse horizontal plane then the sills would take the load equally or to the limit of their capability; this condition, however, will not hold because in practice the bolsters will defect, the action of which will cause excessive loads being placed upon the center sills with less upon the intermediate and little upon the side sills. If the permissible compression of the center sills is sufficient to permit this condition to hold, then the intermediate sills get their smallest proportion.

With no intermediate sills the condition imposed upon the center sills as far as end shocks is concerned is worse. The matter is one of great doubt throughout.

Fundamentally all car frames must carry their own weights and the relatively small proportion of baggage or personal load; it is just as fundamental a fact that they must be formed to resist end shock. What this end shock may be has been covered in general on page 82, February, 1908.

Thus the provisions which are made for these destructive buffing strains must be capable of standing up to the data secured from a most careful study of the conditions under which the cars will operate, so that an analysis of the suitability of any framing design will hence depend upon the service and type of equipment in use.

This form of car should be used for but that type of service which must needs have the smallest end shock; it is not adapted to as large end shocks for economical building as Form I, much less for Form II. It is adapted to every type of car now running, but when electric service is considered, this is not the car it should be on account of the interference of the truss rods or fishbellied side sills with the apparatus underneath the car.

RESUME.

THE UNDERFRAME PROBLEM.

The data upon which this problem is formulated are in general:

"The demands of the service for which the vehicle is intended and the resistances and destructive forces which it must overcome in such service." (See page 453, Dec., '07, issue.)

The sources from which these data are secured are first the operative and passenger departments. In some cases the items of information are definite and complete, and in others must necessarily be approximated. These items include studies of

(a) Traffic and schedules.
(b) Character of trains.
(c) Number of trains.
(d) Speeds and headway.
(e) Ingress and egress facilities.
(f) Seating capacity.
(g) Length.
(h) Permissible weight.
(i) Maximum cost.
(j) Character of motive power.
(k) Allowable clearances.

Other items may be specified and most probably will be, concerning various detail arrangements which must be incorporated.

The service conditions which produce different demands are those for train and separate unit running. (See p. 455, Dec., '07.)

Under these heads would come the problems associated with the probable change of motive power unit and the strength and reliability factors covering end shocks and vertical lading. (See pp. 455 to 459. The more prominent limitations concerning lightness and economy are found on p. 454.)

ARRANGEMENT OF UNDERFRAME MEMBERS. (p. 461, '07.)

FORM I. PP. 81-83, FEB., 1908.

Load Carrying.—The weight of superstructure and lading is taken by the side girder. Buffing and pulling strains are assumed by the center sills.
Utility—Best for nominal end shocks and cars without central side entrances. Good for multiple unit control (p. 81).
Center Sills—Weak and light—nature of a uniformly loaded continuous beam (p. 83) with end load (p. 84 and p. 153).
Transverse Supports—Nature of a simple beam loaded by center sills both vertically and transversely (p. 156).
Floor Girder—Trussed—Plate—Formed of center sills and side sills in a horizontal plane and used to assist in end shocks (p. 156).
Side Girder—Formed of side sill angles—side plates and belt rail with posts as vertical stiffeners. Loaded from the transverse supports and superstructure (p. 235).

FORM II.

Load Carrying—All loads from superstructure, lading and end shocks taken by the center sills (p. 234).
Utility—The best form for severe service with heavy end shocks; can be used for every type of equipment (p. 235).
Center Sills—Box Girder or Trussed—of the nature of a uniformly loaded overhanging beam with end load (p. 236).
Transverse Cantilevers—Double cantilevers—loaded at each end and supported at the center.
Side Girder—Continuous deck beam of depth between side sills and belt rail loaded with superstructure weight and lading which is transferred to center sills through the transverse cantilevers (p. 238).

FORM III.

Load Carrying—All longitudinal sills carry weight of superstructure and lading. End shocks opposed mainly by the center sills.
Utility—Not adapted to as severe end shocks as Form II for economical building.
Center Sills—Uniformly loaded overhanging beam, subject to end shock.
Intermediate Sills—Uniformly loaded overhanging beams.
Side Sills—Uniformly loaded overhanging beams.
Transverse Supports—Endeavor to equalize load carrying of longitudinal sills.

MELTING SNOW AT FROGS AND SWITCHES.

A new method of snow melting by means of a hydrocarbon fluid was described in a paper presented by J. S. Lang, M. Am. Soc. M. E., at a recent meeting of the Railway Signal Association. The practicability of this method, according to Mr. Lang, has been demonstrated by its use for the purpose of freeing switches from snow and ice during the past three winters at one of the busiest terminals in the country. The process is described as follows:

The melting of the snow or ice is effected by applying to it a flaming fluid of special character, which continued to burn while in the snow, melting and finally evaporating the greater portion of it. On account of the special character of the fluid, the flame is easily maintained regardless of the high winds of the storm or the drifting of the snow.

The fluid is applied by the regular track force by means of a safety distributing can, and the height and extent of the flame can be regulated with ease.

No injury to track results from the use of this system, as the temperature of the rails is not raised to the usual summer heat. The fluid is obtainable in the open market at from three to five cents per gallon and may be obtained free of cost by railroads operating their own Pintsch gas plant.

This system is said to be at once more economical and more effective than the common method of "hand cleaning" switches.

PROPOSED FREIGHT TUNNELS FOR NEW YORK CITY.—W. J. Wilgus, formerly vice-president of the New York Central & Hudson River R. R., and now president of the Amsterdam Corporation, of 165 Broadway, New York, has submitted to the Public Service Commission of that city an extensive plan whereby all the freight, mail, express and waste products of the business section of Manhattan are to be transported through underground railroads, which are to extend from several freight terminals to the basements of the shippers and receivers of merchandise. The plan is somewhat like that of the Chicago subways. The scheme contemplates a vast undertaking and is submitted for public discussion and the commission's approval. Mr. Wilgus states that should the project be approved the Amsterdam Corporation is prepared to submit a proposal by which it may be made effective through the granting of a franchise.

THE CUNARD LINER "LUSITANIA," by her westward voyage, completed July 11, achieved the distinction of being the first 25-knot steamer. She covered the long course from Daunt's Rock to Sandy Hook, of 3,891 miles, in 4 days, 19 hrs., 36 mins., an average speed of 25.01 knots per hour. A new record for the longest day's run was also made, 643 knots having been covered during the first day of the voyage. A readjustment of her propellers, which was made in Liverpool, is considered to have aided the ship to attain this speed. Two new forward propellers of four blades replaced the former three-bladed ones. They are solid castings of manganese bronze. The two rear propellers remain as before, with three blades. It is said that this arrangement also did away with all vibration.

DAILY RAILWAY AND ENGINEERING REVIEW.—During the week of the tenth annual convention of the Railway Engineering and Maintenance of Way Association, and the exhibit of the Road and Track Supply Association in Chicago, beginning March 15, 1909, *The Railway and Engineering Review* will issue a daily paper each morning, except Saturday.

RAILWAY BUSINESS ASSOCIATION.

An important meeting of the manufacturers of railroad material and equipment was held at the Waldorf-Astoria, New York City, on the evening of September 30 for the purpose of forming a permanent organization whose object should be to obtain united action in systematic efforts for the conservation of the interests of the railroads. The Association, called the "Railroad Business Association," was formally organized and the following officers elected: George A. Post, president; H. H. Westinghouse, O. H. Cutler, W. H. Marshall, E. S. S. Keith, A. H. Mulliken, O. P. Letchworth, vice-presidents; Charles A. Moore, treasurer, and W. P. Pearce, William V. Kelley, Col. H. G. Prout, J. S. Coffin, N. Paul Fenner, E. L. Adreon, J. H. Schwacke, A. M. Kittredge and John F. Deckson, executive committee.

It was thoroughly impressed upon all of those present that this association is strictly non-partisan; it has, and is to have, nothing at all to do with politics. It has no axe to grind other than to see that fair play is given to the railroads. It does not attempt to excuse the misdeeds of railways, but exists for the purpose of attempting to guide and form public opinion so that the railways will be accorded the credit due them from the public and be given a chance to counteract the results of the work of the demagogue and agitator. The reasons for an organization of this kind are best given by some extracts from the address delivered by George A. Post, president of the Standard Coupler Company, who acted as temporary chairman of the meeting. He stated in part:

When railroads are prosperous, times are good everywhere; when railroads are not prosperous, jobless hordes are in despair, and the cupboards of workingmen are bare. Largely responsible for this paralysis afflicting our railroads is the attitude of harsh hostility toward them, as manifested in federal and state administrative and legislative circles. Because of this hostility, confidence of investors in their prospective profitable operations, and in the stability of values of their securities has been seriously undermined.

To denounce railroads and railroad officers, and to scheme for their discomfiture, has become epidemic among many people otherwise rational. So persistent has been the indiscriminate condemnation of railroad managers, that it has come to be considered a necessary ingredient of the vocal output of those who seek popular favor to gain political preferment. In the absence of any other qualification for the exercise of political power, the aspirant has deemed it sufficient to declaim vehemently against railroads and to give assurance that condign punishment shall be meted out by him, if elected, to those who control the means of transportation. No legislative anti-corporation bomb could be too deadly to please people who are frenzied in their opposition thereto.

* * * * * * * * * * *

To attain the knowledge and experience wherewith properly and successfully to operate a railroad is a tedious process. The preliminary training covers many years of patient toil and profound study of the subject, and is then only possible of attainment by those of a high order of intelligence. And yet, it has come to pass in this era of hysteria that such men and their views regarding railroad operations are tabooed. The popular conception of the true railroad scientist is one who never spent a day of his life in railroad service, but whose mental activities have been applied in other occupations far removed from the possibility of acquiring railroad knowledge. It is a peculiar fact that a trained railroad man will frankly disavow any knowledge of how to conduct any other business, but you seldom find a man running any other kind of business, whether successfully or otherwise, who does not consider himself a competent critic of railroad management.

The railroads of America are just now the victims of a powerful and vindictive wrath trust. We hear much of the depredations of trust magnates, and the injustice and oppressions of predatory wealth. But what of the devastating attacks of "predatory wrath" upon railroads? There has been an amalgamation of all the small local hostilities to railroads that have been started—here through the peevishness of some station agent, there through the brusque manners of an uncivil train man, elsewhere by the avarice of some wicked stock jobber, or, in some quarters, by the frosty pomposity of some railroad executive. These wrath factories have poisoned the minds of whole communities, and sharp-tongued representatives have enlisted the antagonism of counties. Ignited by the fiery objurgation of excited orators, states have become mammoth furnaces wherein discontent has seethed, hissed and blazed. From these fires of wrath, sparks in the shape of ambitious, cunning, self-seekers have been shot into the municipal, county, state and federal councils, there to set fire to the imagination, the hopes, the fears, and cupidity of the populace, and to hurl fire-brands of inimical legislation into the camps of the railroads. Onward has spread the work of consolidation.

* * * * * * * * * * *

It has been a great, fat feast for predatory wrath makers. They have roamed abroad throughout the land, putting crimps in railroads that make them writhe in the agonies of depleted revenues and that have emptied the dinner pails of an army of railroad employees.

No trust that was ever organized in this country has it in its power to create the thousandth part of the havoc, rob so many people of employment, strike terror to the hearts of investors and diminish the incomes of widows and orphans as has this same juggernaut of agitation—the wrath trust.

Its vengeful progress must be checked. The hour has struck when courageous men must form a wall of human adamant and resist it. If ever again good times shall return to bless us; if ever again we may boast of American prosperity; if ever again confidence shall be restored in business circles, there must be an end to this frenzied fulmination against railroads, and calm reason must bear sway in the solution of the intricate problems that confront us.

* * * * * * * * * * *

In any dispute the right is seldom all on one side. All the zeal for gain and commercial advantage in this country is not confined to those who manage our railroads. Every shipper is not a saint, nor is every common carrier a demon. Not every complaint lodged against a railroad is founded in truth and equity. A large percentage of the hue and cry against railroads is simply the vaporings of chronic growlers, who growl at railroads as they growl at their neighbors, or find fault with their family's expenditures.

It is true beyond a doubt that there have been in the past and are at present many things in the conduct of our railroads that were not and are not right, and against which protest has been and may be rightly made. To deny this would be silly, and would render abortive at their inception any efforts that we might make in behalf of railroads. If we would be influential in our friendship for the railroads, our attitude must not be that of condonation of any wrong, but staunch advocacy of fair play all round. We are manufacturers of railroad materials, not vendors of taffy.

There is serious work to be done. We want orders. We want to see the fires lighted in our furnaces, profits flowing into our coffers, workingmen made glad by the joyous sound of the shop whistles calling them from idleness to work. Not one of these hopes can be realized until railroads are relieved of the incubus of hostile agitation that now halts their successful operation.

It is admitted that some reforms are necessary and desirable in the conduct of railroads, to the end that discontent may be quieted. It is conceded that as public servants, exercising the great powers conferred upon them by the people, intended for the public good, and possessed of franchises of untold value, granted them by legislation, railroads should be subjected to proper regulation and supervision by the people through constituted authority. But there is a vast difference between healthful, sane regulation and vicious strangulation. Not every carping critic is a Solomon; nor is every lawmaker a statesman. Because a law is aimed at a railroad does not necessarily make it right or expedient; it may be wrong and work injustice. Hot-headed legislators enact hot-headed legislation. Statutes conceived in wrath have their fruition in paralyzed commerce. As abaters of the smoke nuisance they have our inventors in that line lashed to the mast.

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The thoroughly trained, capable and honest officials, whose energies and brains are concentrated upon the problem of conducting the business of railroads profitably to their owners and satisfactorily to their patrons, should be upheld and their work appreciated. They are, in fact, the overwhelming majority.

Those railroad officials who vex the public by temperamental failings, who are brusque and inconsiderate in their intercourse with the public, must be brought to realize that they are in fact public servants and not monarchs.

Those who may be guilty of wicked practices, in the administration of railroad properties, should be scourged with the lash of universal scorn and driven from the railroad field.

Those who decry railroads with malicious intent; who would cripple them to gratify personal spleen, or for personal aggrandizement, must be exposed and their power for evil destroyed.

Those who criticize railroad methods intelligently; who have just cause for complaint in their dealings with railroads, must be accorded respectful audience and be listened to with ears anxious for the truth.

Those who depend upon railroads for subsistence, directly or indirectly, must be loyal to their means of support, and quick to resent interference therewith by crafty or turbulent trouble makers.

Railroads must be operated with a fair margin of profit, else they cannot maintain efficiency in equipment, adequately meet increasing demands for terminal facilities and other betterments, nor can they pay good wages to their operatives. In other business enterprises, it is a maxim that prices include a profit. If there are no profits, there is bankruptcy. There is no reason why transportation rates should not be adjusted upon the same basis.

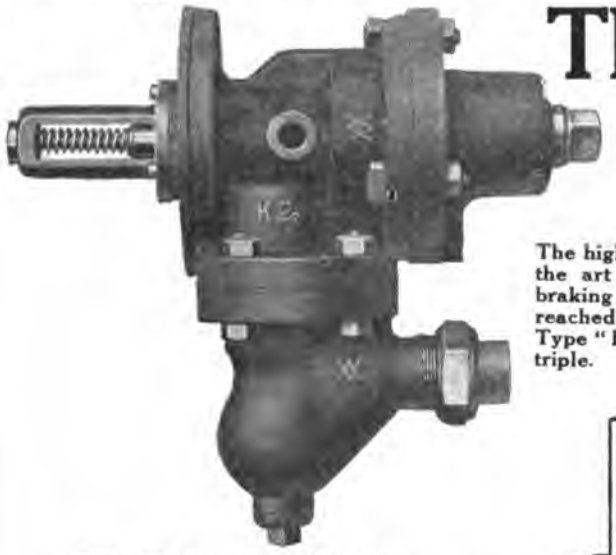
* * * * * * * * * * *

All these things can be accomplished. They must be accomplished. Who are better equipped than bodies of men such as are here assembled, to aid in their accomplishment?

CAR SHORTAGE ON C. P. R.—In a special report by the president of the Canadian Pacific, he said that during the last six years the company had spent $37,000,000 for locomotives and cars, and yet during the next six weeks there would hardly be enough cars to handle the business offered.

Westinghouse

Steps in the Evolution of The Freight Brake



Type "K" Freight Triple Valve

The highest step in the art of freight braking has been reached by the Type "K" Freight triple.

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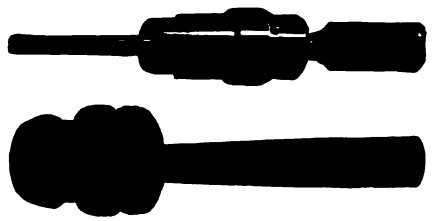

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